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Dear Dr Brend.

Thanks for your letter. I am glad the perusal of the book affords you pleasure.

Yours sincerely
John Bland-Sutton

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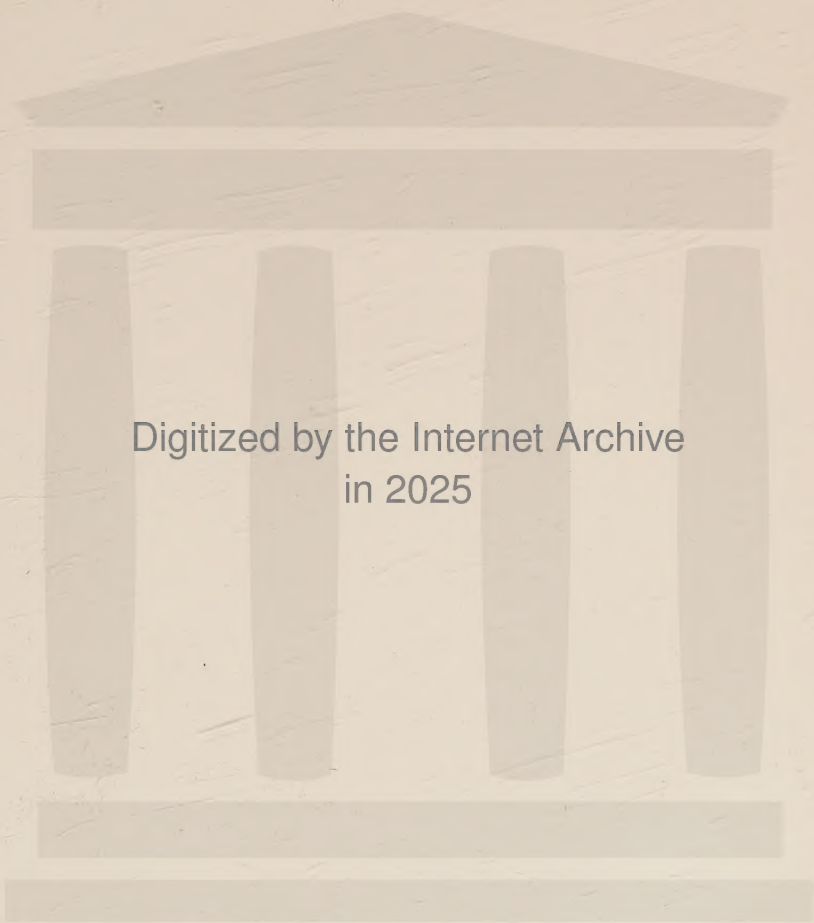
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JOHN HUNTER.

The picture is by Robert Home, his brother-in-law. The odd dog is supposed to be the offspring of a half-bred wolf-bitch and a mastiff.

ORATIONS AND ADDRESSES

BY

SIR JOHN BLAND-SUTTON

Consulting Surgeon to the Middlesex Hospital.

LONDON:

WILLIAM HEINEMANN

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1924

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PREFACE

THE Orations and Addresses in this little book were delivered in divers places, and published in sundry journals. It is vexatious when asked, when and where such and such an address was delivered and published, not to be quite sure of either. As a bundle of reprints of varying shapes and sizes forms a zig-zag as odd as a camel yoked to an ass, or an ox yoked to a mule, or all four together tugging at a wain, I have collected a few in a uniform volume as being a convenient method of sending them to friends—and critics. There may be, also, a little vanity in imagining that friends may like to possess them as mementos.

In re-editing the addresses, the author recalls his interest in writing, and the inspiration he derived in delivering them.

J. B.-S.

1924.

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I

JOHN HUNTER (1728–1793): HIS AFFAIRS, HABITS, AND OPINIONS

(The Hunterian Oration delivered at the Royal College of Surgeons, England, February 14th, 1923).

My knowledge of John Hunter began in a curious way. In my ninth year I was taken to see his famous house at Earl's Court, and shown the den in the garden where he kept wild beasts in order to study them. Being fond of animals, this made a deep impression on my mind. In the simple religious exercises of my childhood, the story of Adam and Eve, the first keepers of a zoological garden, and the famous exploit of Noah, collector and preserver of wild animals, had great charm for me. Some years later the visit came vividly to my mind on finding a dilapidated copy of Ottley's Life of Hunter, which I read eagerly. Ever since I have been deeply interested in all that relates to this extraordinary man, and the preparation of this oration has been a delightful and engrossing occupation.

Long Calderwood (1728–1748).

John Hunter was born at the farmhouse, Long Calderwood, near Glasgow. The house bears a tablet to the effect that he was born Feb. 13th, 1728. In his lifetime the birthday was kept Feb. 14th, and this College drinks to his memory in "solemn silence" on the 14th. Like myself, he was probably born so late at night that in the hurry-scurry the midwife failed to notice whether he appeared just before or shortly

after the clock struck 12. John, or Jockie, as he was called at home, the youngest of a family of 10, petted by his mother (his father died in 1741, aged 78), disliked school and hated books. He preferred to lead an out-of-door life, looking after nests, insects, and animals, whilst his brothers got the same education as country gentlemen. At the age of 17 he spent some months with a brother-in-law, a timber merchant and carpenter in Glasgow, and we can well believe he tried his hand with tools ; his mother noticed that the "lad showed neatness of hands and quickness of perception in anything that regarded mechanism." What inquisitive boy has not meddled with awls and gimlets, mallets and chisels, hammers and nails, saws and planes ? Sharp boys can learn much that is useful in workshops, and a training in joinery teaches neatness and precision. Looking back it is instructive to consider how the farm life fitted John Hunter for his subsequent career. The practical surgeon is a craftsman ; Greek and Latin are useful to him for polish, but think of the natural knowledge a smart boy can collect on a farm about the sowing, sprouting, and ripening of crops, the breeding of animals, gelding of colts, spaying of pigs, caponising of cocks, fattening and slaughtering of animals for food, farriery—shoeing and doctoring of horses —observing the wild life in ponds and ditches, fields and hedgerows, trees and heather. In the village he can watch the wheelwright, smith, tinker, glazier, cobbler, and cooper, all experts with simple tools. *Practical knowledge of this kind was useful in that state of life unto which William Hunter called his youngest brother.*

Human Anatomy (1748–1760).

At the age of 20 John Hunter came to London with the object of assisting his brother William, who had a school of anatomy at the back of his house in Covent Garden. John showed unusual skill in dissecting, worked hard, liked the

companionship of men of his own age, and was fond of the theatre. There can be no doubt that he was an example of the medical student skilfully described by Dickens in "Pickwick Papers," 1836, and Albert Smith in *Punch*, 1841. Human anatomy appealed to this uncouth Scot, and William Hunter, a cultured man, moulded John's character, and "bred him to

FIG. 1.—The nerves on the nasal septum (Hunterian).

anatomy" in its widest significance with astonishing results. In the summer of 1754 Hunter was busy studying the routes by which the branches of the fifth nerve leave the skull. He unravelled the branches of the olfactory nerve, traced the course of the naso-palatine nerve, and the rambling nerve known as the nasal branch of the ophthalmic division of the fifth; a specimen (Fig. 1) he dissected to show these nerves exists in the Museum in excellent condition.

Hunter's attention was arrested by the uniformity in the course and distribution of nerves in comparison with the vagary of blood-vessels. Even now few grasp the problem presented

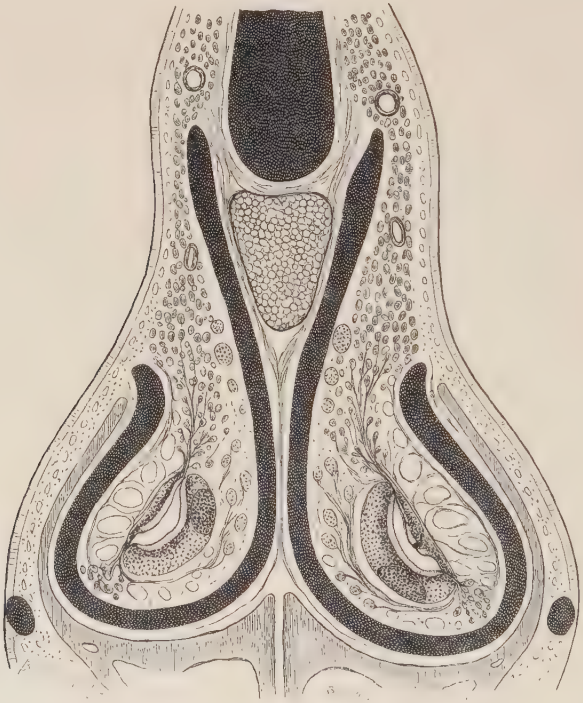

Fig. 2.—Section of a rabbit's nose exposing Jacobson's organ (Klein).

by the branches of the olfactory nerve, which run down the anterior border of the nasal septum. In 1811 Jacobson, a surgeon in the Danish Army, discovered a curious organ lodged in a scroll of cartilage situated on the anterior part of the base of the nasal septum (Feb. 2).

Jacobson's organ—a vestige in man, apes, and whales—is well developed in many mammals. Little is known of its function, but the specialised cells lining its cavity receive the olfactory twigs detected by Hunter. Jacobson's organ is well developed in mammals with long snouts, especially insectivora that find food at dusk ; rodents whose young are born blind and live in deep burrows, and kangaroos whose young must find their way into, and pass many weeks snugly ensconced in the mother's warm pouch. The prime service of olfaction is the quest for food. The sense of smell is of first-rate importance to mammals born blind—*it enables them to find the teats of the mother.* The vomero-nasal organ is subsidiary to the olfactory nerve.

The morphology of the canals and foramina by which the cranial nerves leave the skull has always fascinated me, and many delightful hours of my life have been spent unravelling the secrets connected with their methods of exit, re-entrance, and final escape from the skull. The study interested Hunter apart from its morphological aspect. In his days vestiges were merely anatomical curiosities. How much greater the interest for us studying them in the light of man's evolution! For Hunter, morphology was a gleam in the intellectual sky. We revel in the sunshine. Morphology has become the soul of anatomy.

Many regard the dissection of the human body as a repulsive exercise. Teachers of anatomy know well that many begin to dissect with disgust and overcome the distaste ; others continue the study because it fits a man for the medical profession. Some who have found difficulty in retaining or appreciating the facts of anatomy have shone in other professions. On the other hand, men unable to grasp mathematics or the principles of physics have become proficient anatomists. In a few instances men working at a humdrum calling turned to anatomy more or less accidentally and pursued it with zeal.

It is easy to understand that the uncouth, unschooled, apparently idle Jockie Hunter when introduced to the dissecting-room became deeply interested in the structure of the human body and found it an absorbing study. *Verily the gunpowder of genius is stored in many brains, but—it needs a match.*

Belleisle (1760–1762) and Marine Zoology.

Hunter, during the first period of his life in London (1748–1760), acquired a practical knowledge of human anatomy, but this was mainly a study for the winter months. During the summer he studied surgery, following Cheselden for a season, also Pott, but St. George's Hospital offered better opportunities, and he joined as surgeon's pupil, and later had the good fortune to serve as house surgeon for two years, an invaluable experience. Whilst engaged in the routine of dissecting and teaching he developed a taste for comparative anatomy which became an absorbing passion, enhanced by a change of locality. In the spring of 1759 he had some lung trouble which made it necessary for him to seek change of climate. In 1760 a force was sent from England to take Belleisle, an island near the mouth of the Loire. Hunter applied for an appointment with the expedition and served as staff surgeon. This gave him a chance of obtaining practical knowledge of gunshot wounds.

Belleisle, well named, is a pretty island now almost tree-less. It is a plateau of 33 square miles, about 130 feet above sea-level ; here and there slopes give access to beautiful tracts of white sand. The coast has many grottoes. The most remarkable is La Grotte de l'Apothicairerie, a sanctuary for sea-birds, and their nests in rows on ledges of the rock are supposed to resemble bottles on the shelves of a pharmacy. I spent a week in this island and realised what a change it proved for a man from London, ardently pursuing comparative anatomy. A country new to him in flora and fauna. He took advantage of it by observing, collecting, dissecting, experimenting, and preparing

and preserving specimens. Hunter had no knowledge of marine zoology until he landed on this charming island, which afforded him access to barnacles, sea-anemones, sea-stars, sea-nettles, sea-cucumbers, sea-squirts, sea-urchins, squid, huge spider crabs, tunny-fish, and conger eels.

While studying and dissecting these animals the idea came into his mind that living creatures could be arranged in a physiological series, but he was puzzled to ascertain the use of strange organs he met with in marine invertebrates. Like Cuvier, he had to rely on naked-eye dissection, but dissection, however skilful, does not enable anatomists to determine the minute structure of soft organs which is the key to function. These difficulties are shown in Hunter's studies of the reproductive organs of eels. He truly observes "the production of animals out of themselves excites wonder and curiosity." The precise manner in which it is carried out has required centuries of observation for its demonstration. The eggs of flies, butterflies, fishes, frogs, turtles, crocodiles, snakes, and birds appeal to the simplest mind. It was difficult to prove that

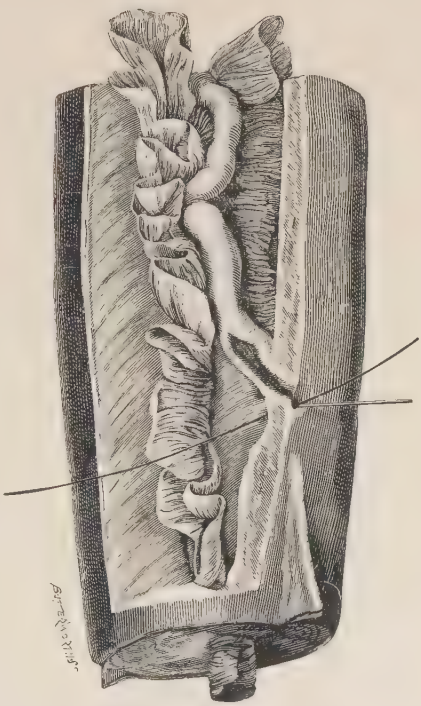

FIG. 3.—Segment of an eel showing the ovary. The bristles mark the end of the rectum and the abdominal pore (Hunterian).

mammals came from eggs, for their small eggs require a microscope to make them visible. This is true of mice and men.

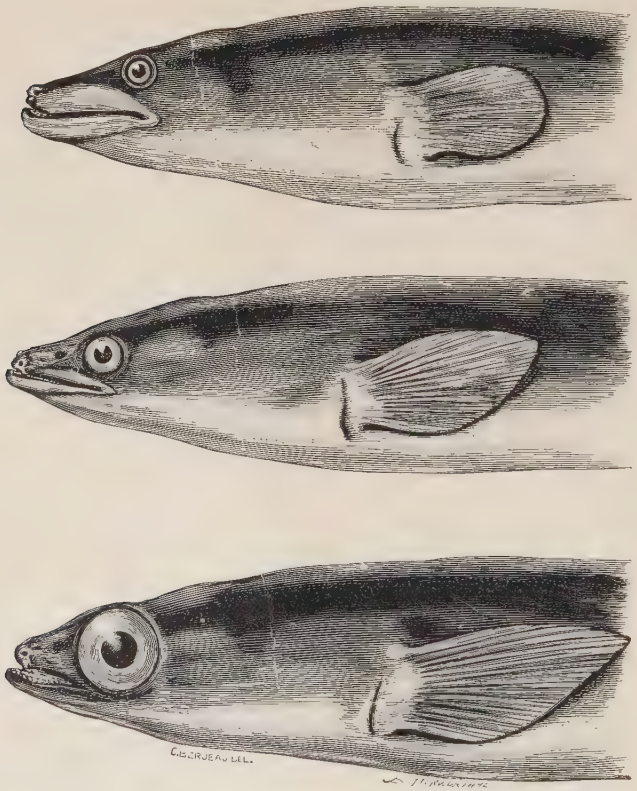

FIG. 4.—Drawings showing the change from the yellow eel with thick lips, small eyes, and compact fin, into the large-eyed silvery eel, which migrates to the ocean, where it reaches maturity, spawns and dies. (From models in the Natural History Museum.)

In London he got eels every month of the year from a fishmonger and examined the parts he expected to be the ovary

with a magnifier but without result. When he was in Belleisle, in the summer of 1761, there was a vast number of conger eels in the sea around the island ; he dissected many and satisfied himself that the ruffle-like organs he regarded as ovaries in the common eel were ovaries (Fig. 3), but he did not solve the mystery of the propagation of eels. In 1896 Grassi discovered that eels needed salt water for the development of their reproductive organs and the deep sea is their spawning place. In autumn they migrate to the sea and the dull yellow of their skin changes to silvery glitter ; the eyes enlarge, the pectoral fins become black and change in shape (Fig. 4), and the ova ripen.

Mature eels cease to feed and after spawning die. Recently hatched eels, called *Leptocephali* on account of the small size of their heads, are transparent and free from colour, except the eyes, which shine through the water like black beads. When about 7 cm. long *Leptocephali* cease to feed and change into elvers, which in spring find their way up the rivers in enormous numbers. The migrations of eel-fry are astounding in extent and duration. In some instances larvæ will traverse a quarter of the circumference of the globe to complete their life-history (Schmidt). Elvers in fresh water transform into eels, and in their turn descend the rivers, seek the depths of the sea, where decked in glorious sheen they spawn and die.

Although Hunter did not get on well with his senior colleagues at Belleisle, he was comfortable on his pay, and enjoyed the opportunities for studying natural history, but in 1762 a British expedition to Portugal was the topic of conversation ; he was keen to go, and his brother William helped him with the authorities in London to do so.

Portugal and Geology (1762–1763).

One of the last episodes of the Seven Years' War was an attempt on the part of France and Spain to invade Portugal.

The French and Spanish forces were collected at Ciudad Rodrigo with the object of advancing on Lisbon along the Tagus valley. England decided to support Portugal, and an expeditionary force of 7,000 men was sent to Lisbon. The British and Portuguese troops, under the command of Count Schambourg-Lippe, an able officer trained in the school of Frederick the Great, assembled on the banks of the Tagus near the Spanish border. The outstanding feature of this almost forgotten campaign was the use, for the first time, of light cavalry which General John Burgoyne was instrumental in introducing into the British army. Under Burgoyne the cavalry rendered distinguished service at Valencia d'Alcantara and in some sharp fighting at Villa Velha. The campaign was concluded by the Peace of Paris, 1763. Mr. Robert Boyne Home was the surgeon attached to the regiment of light horse. John Hunter, transferred from Belleisle to Portugal, was in charge of a hospital. Hunter landed at Lisbon, July, 1762, and in November of the same year he was at Portalegre, near the Spanish frontier, 140 miles from Lisbon. General headquarters was at Estremoz, 30 miles south of Portalegre, and on the direct road to Lisbon. Little is known of his doings in Portugal, and it has been supposed he made additional observations on gunshot wounds ; for this there was not much opportunity, but with a force of 7,000 men there would be accidents and sickness incidental to a campaign in a foreign country.

It is certain that in Portugal Hunter made observations on natural history and collected specimens, some of which are preserved in the Museum, but the most important gain was an inspiration to study geology. The hill on which Portalegre is built stands on a remarkable plateau called Alemtejo (spelt Alentejo in 1763). In an extraordinary tract published about 50 years after Hunter's death, under the title " Observations and Reflections on Geology," he refers to the extensive plateau called Alentejo, which shows evident signs of its surface being

covered by the sea, and refers to the enormous heaps of granite so frequent on the plain. The tract not only contains remarkable observations on geology, but some ideas on the distributions of animals in relation to the antiquity of the world inconsistent with the creation as described in Genesis. He abstained from publishing it on the advice of friends. Recently I visited Portalegre, the Alemtejo, and the surrounding country, and satisfied myself that Hunter while living on the plain had excellent inducements to study botany as well as geology, for he was among a sub-tropical flora, and at Lisbon he had opportunities of collecting specimens and adding to the knowledge of marine zoology he had acquired at Belleisle.

Hunter's domestic life was influenced in an important manner by the affairs of Portugal, for Home, surgeon to Burgoyne's regiment of light horse, became his friend. Hunter on his return to England got engaged to Home's daughter Anne. It was a long engagement, for they were not married till 1771. Mrs. Hunter's younger brother, Everard, became Hunter's house-pupil, then his assistant, and finally executor.

Sir Everard Home and Matthew Baillie founded the Hunterian Oration in 1813 and Everard Home was the first orator, 1814.

Earl's Court.

On the conclusion of peace Hunter returned to London a staff surgeon and deputy purveyor on half pay. He took a house in Golden Square and started to practise. His half pay, probably half a guinea a day, helped to pay the rent. He opened a room for dissecting, made teaching preparations, and while waiting for patients, like many of us, taught human anatomy for capital and comparative anatomy for interest. The classes were neither large nor lucrative, for he was not a good lecturer. In 1765 he bought the lease of three pieces of

land at Earl's Court, built a house, established a small menagerie, and made observations and experiments :

> On gizzards of gulls, hawks and owls,
> The heat of lizards, spurs of fowls ;
> Bones of pigs, air-sacs of eagles,
> Moaning dingos, barking beagles ;
> Sleek opossums, prickly hedgehogs,
> Buffaloes, dormice, wolves and dogs.

Leopards and jackals lived in the den, buffaloes, stallions, sheep, goats and rams occupied the stables. A mulberry tree furnished leaves for the silkworms, and St. John's wort supplied pollen for bees. There was a pond for the ducks and geese which laid eggs for the table and for embryological studies. He made observation hives for the bees, discovered that their wax is a secretion, and left some excellent notes on the relation of vegetables to animal fat. With the aid of Ramsden's delicate thermometers he discovered the significance of the terms hot-blooded and cold-blooded animals. He would have been astonished to learn that muscular action is the main source of animal heat ! Hunter failed to grasp the importance of measuring the temperature of the body for clinical purposes. Indeed, its value was not appreciated until the middle of the nineteenth century.

Earl's Court remained a bachelor's residence for seven years. In 1771 John Hunter, aged 43, married Anne Home, aged 29, a charming, amiable, and accomplished spinster, who, in due course, added to the physiologist's paradise the most delightful of all objects of natural history—children. Mrs. Hunter had a brother, Robert Home, an artist, who painted a portrait of Hunter which eventually came into the possession of the Royal Society (*Frontispiece*). In 1787 Hunter read a paper before that society on some observations " tending to show that the wolf, jackal, and dog are all of the same species." The odd dog in the picture is supposed to be the offspring of a half-bred

wolf bitch and an English mastiff. The dog died in 1782. The portrait represents Hunter about the age of 45. He describes himself at this period in a letter to James Baillie, his brother-in-law, as " one of the happyst men living " (1785), in spite of the fact that he had to raise money on the Earl's Court property, a fact concerning which Dr. G. C. Peachey has found unimpeachable documentary evidence. Hunter was a resident at Earl's Court 30 years. In 1877 the Royal College of Surgeons, and a few friends, placed a window to his memory in St. Mary Abbott's Church, Kensington. One of the principal lights represents St. Paul on the island of Melita casting a viper off his hand.

The Museum.

Nothing is known of the time Hunter began to collect specimens with the definite object of establishing a comprehensive museum of comparative anatomy. The museum owes its origin to the peculiar conditions under which medical education was carried on in London in the eighteenth century. Schools of anatomy were private ventures. It was necessary for the surgeon who owned and managed the school to illustrate his lectures with skilfully prepared specimens. Such preparations are more useful than diagrams, wax models, or drawings on blackboards, even when made with skill and coloured chalk. Hunter made many preparations for his brother, and some exist in the Hunterian Museum at Glasgow, but when he returned to London in 1763 he brought with him specimens of natural history from Belleisle and Portugal, and these formed the nucleus of the collection for illustrating comparative anatomy. It is a fair inference that the specimens were collected to subserve teaching purposes directly connected with his lectures, but it grew and widened until it became a museum that could be regarded as a discourse on the human body in relation to the animal kingdom. Gradually its founder's ideas expanded, and he conceived that it should be an ample illustration of life

exhibited in the vast chain of organised beings, living and extinct, by a display of the various structures in which the functions of life are carried on.

In 1783 the lease of the house, 42, Jermyn Street, which he had acquired from his brother William, expired. He then took premises in Leicester Square and built his famous museum. Sir Joshua Reynolds lived in the square, and the two men subsequently helped each other to what artists jokingly call immortality—one as subject, the other as painter. The famous picture is the most cherished possession of our College. When Baron Grant furbished up Leicester Square and laid out the garden in 1874, a colossal bust of Hunter was placed in one corner and a bust of Reynolds in another.

Hunter's example in collecting specimens was contagious. Blizzard, Astley Cooper, Heaviside, and other surgeons formed collections, now dispersed. The care entailed in the maintenance and supervision of such museums is very great. Hunter's museum nearly perished. His executors, Matthew Baillie and Everard Home, with sound judgment, retained the services of William Clift, who preserved the specimens from decay by the judicious use of two gallons of spirit occasionally. He had no books, so he read and made extracts from Hunter's manuscripts. The transcripts were made from some of the notes afterwards destroyed by Everard Home. They were published by Owen under the title "Essays and Observations," in 1861. For seven years Clift received 7*s*. weekly and meekly as wages. In return for these services he became the first conservator when the Government bought the collection and intrusted it to the College of Surgeons in 1800. Clift was conservator till 1842. The museum contains in orderly array, big and little, of every living thing Hunter could secure. Shrimps and sharks, humming-birds and ostriches, shrews and whales. Of the human kind, dwarfs and giants. Animals now living on the earth were not enough, he must have fossil

forms. The fame of Hunter was such that new or rare animals were brought to London for his opinion. When John White returned to England (1790) from New South Wales "the nondescript animals of that settlement"—kangaroo, potoroo, tapua roo, and the like, were handed to Hunter for investigation. The museum is now so rich in specimens illustrating the anatomy of vertebrates, living or extinct, normal and abnormal, that no one who is prudent ventures to publish anything he thinks new without examining the correlated specimens in the museum. It abounds in surprises, and is in a sense an anatomical Valhalla.

Pathology.

Specimens illustrating "diseased action" were preserved in the museum. Pathology is a department of biology. Hunter's ideas of many pathological processes were crude; without the aid of a compound microscope, section-cutting and staining methods, his knowledge of tumours was not above that of the farrier. Shepherds talk of corns, warts, blains, wens, and blemishes. The slaughter-house supplied him with melanotic tumours from oxen, and from the knacker's yard he got similar things from horses. Graveyards yielded calcified fibroids and tumours of bones. In Hunter's day, and for many years afterwards, pathological specimens were mainly spoils from the dead-house; to-day they are prizes from the operation theatre.

The history of surgical progress during the last 50 years can be traced in the museum catalogue. The hall in the museum that enshrines Hunter's statue is a Temple of Pathology, admirably arranged and catalogued by Shattock. It should stimulate surgeons to study the *science as well as practise the art of surgery.*

Embryology.

Hunter took keen interest in monsters, not from curiosity, but as part of a great scheme showing the phases of life. The collection of malformations in the museum is the finest and

most comprehensive in the world. He was aware of the importance of a knowledge of the developmental stages of animals, and applied himself to study the chick. He studied the goose because its chick is bigger than that of the fowl. He tried the swan but could not get sufficient eggs. He tried to obtain ostrich eggs but only got two in 30 years, and made nothing out of them. The flock of geese for embryologic work

Fig. 5.—Alsatian wolf-hound bitch, whose puppies had died, suckled six little pigs. (*Veterinary Journal*, 1920.)

was kept at Earl's Court for 30 years. Although he obtained much first-hand knowledge from this work and some excellent drawings, he discovered little of importance, but left among his notes, awkwardly expressed, for masters of science are rarely masters of style—*Embryology indicates the steps by which higher forms in a group of animals have been evolved from a lower.*

Hunter clearly recognised the importance of studying the developmental stages of animals, and 30 years after his death von Baer discovered the human ovum and realised that embryology is the key to the knowledge of the human body.

Hunter collected books but read little. Probably he never read the "System of Philosophy" written by Lucretius, although both men reasoned on inexplicable things.

Lucretius.—Before the horns of a calf appear and sprout he butts when angry and pushes passionately. But the cubs of panthers, and lion's whelps, already fight with claws and feet, and biting when their teeth and claws are scarcely yet formed.

Hunter.—A young duckling runs into the water the moment it sees it.

A hen with ducklings seeing them run into the water is unhappy.

A duck with chickens tries to induce them to enter the water—they run about the bank.

In relation to these paragraphs it may be stated that microscopes and serial sections, aided by the most exquisite stains, throw no light on instinct. Though dogs and pigs do not interbreed, the maternal instinct may be so strong in a bitch that she will suckle a sow's orphans (Fig. 5). *Pity is not an exclusive attribute of gods and men.*

Feather-Thickets.

In March, 1778, Hunter made this request of his old pupil and friend, Jenner :—

When you have a blackbird's nest—viz., one with four young ones—take one and put it boldly into spirit by the head, extending the wings and legs. Observe when the feathers begin to sprout, then take another, and serve it in the same way ; then take another and fourth, so as to get a series of the growth of feathers ; but the last or fourth, must not be so old as the feathers to cover other parts where feathers do not grow. This you will understand better when you come to make the trial.

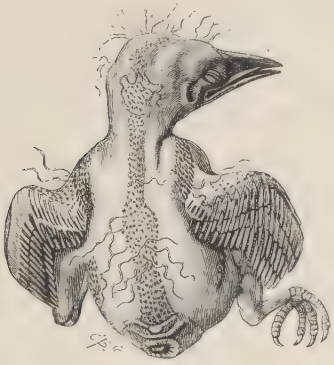

Fig. 6.—Callow Blackbird (Owen).

Jenner carried out these instructions admirably (Figs. 6 and 7). About 40 years after Hunter's

death Owen found among the MS., transcribed by the faithful Clift, some notes on the situation of feathers :—

Although the feathers of birds appear to be an entire and uniform covering they do not arise equally from every part of the body, but only from such parts of the skin as are least likely to be affected by the motion of the contiguous parts, such as the motion of the limbs. The feathers

Fig. 7.—Nestling Blackbird (Owen).

arise pretty equally on the head where there is no motion ; and along the back ; on the wings between joint and joint, as also on the thighs and legs, the whole making the bird a partial coat of mail. As they do not arise from every part of the skin equally, they must be proportionally thick set where they do arise. The places of origin of feathers are very observable in a bird that has been plucked ; but still more so in young birds just feathering, more especially of such as have little down, and of which the clumps of feathers, from their colour as in the young blackbird, present a great contrast with the skin. In the interstices of the clumps of feathers there are others disposed irregularly, but so sparingly as not to interfere with the motion of the part.

Hunter named each feather-thicket according to its situation. In 1833 Nitzsch, unaware of Hunter's observation, published "Pterylographia Avium," a study of the distribution of feathers. He called the thickets, *Pterylæ*—feather-forests, and the featherless spaces *Apteria*.

Pterylosis.—The arrangement of feather-tracts is now used by ornithologists as an aid in the classification of birds. Oken cast ridicule upon it; he could not refrain from laughter when he looked at the plates in Nitzsch's book, since they reminded him of the plucked fowls in a poulterer's shop! We must admit that the idea is comic. Newton referring to this joke, adds: "It might as well be urged as an objection to the plates in many anatomical books that they call to mind a butcher's shop!" Hunter had his jibe at the systematists, for, in his opinion, natural historians are more pleased if they can class an animal, than they would be if they could find any use such an animal would be to society.

The value of the feather-distribution (pterylosis) in classification depends on the fact that feather-tracts, like beaks and feet, are modified by the habits of the bird. These callow blackbirds are as instructive as a parable. They prove Hunter's skill in selecting and preparing specimens for the museum. The contrast in colour—black and white—is excellent, and the skill shown in mounting them undeniable. They were prepared in 1778, and remained in obscurity until Owen found them 40 years after Hunter's death.

Hunter had a great power of observation, but lacked the gift of exposition. His discovery was like a lighted candle under a bushel. Half a century later Nitzsch detected the value of pterylosis and urged its importance in classification in spite of ridicule. It is one thing to discover a new fact, but it is another to make contemporaries accept it, or appreciate its value.

The Horse.

Hunter studied the horse carefully as an anatomist, and as a surgeon. It was natural that he should study an animal that can walk quickly, amble easily, trot gracefully, or gallop with exceeding swiftness on limbs, each of which ends in a modified toe or finger, and in spite of so many anomalies be useful to man. He was thoroughly familiar with equine anatomy, the teeth especially, and left a careful description of the curious guttural pouches, connected with the pharyngeal orifices of the Eustachian tubes, which are often a source of inconvenience to

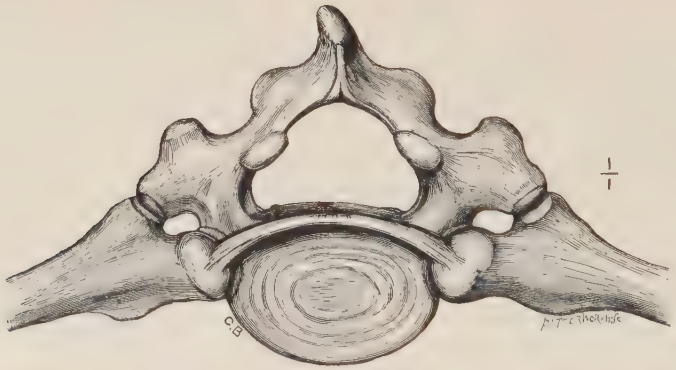

Fig. 8.—Conjugal ligament of the seal.

horses ; and he discovered the curious conjugal ligament which connects the heads of the ribs on opposite sides of the spine. This ligament, well developed also in the seal (Fig. 8), is homologous with the transverse ligament that keeps the odontoid process in position, and which excites curiosity in every human anatomist. Scattered among his " Observations " there are many references to morbid changes in horses and cattle, and in the museum there are specimens illustrating tumour diseases of horses, oxen, sheep, and pigs.

Hunter helped to found the Royal Veterinary College, 1791 ; he was a vice-president and, with Cline, served on a committee that approved of the appointment of Vian St. Bel as the first professor of the College. Among the first operations performed by St. Bel was one for the removal of "two accessory feet which grew from the fetlocks of the two forelegs." Hunter assisted and gave him some useful and friendly hints in the course of the operation, which was followed by good consequences. St. Bel died in 1793, probably from glanders. His early and unexpected death led to some difficulty, and Hunter, in order to help in the emergency, arranged for the students to have admission to the lectures of the leading teachers in the hospital. The names mentioned in this connexion were Dr. Fordyce, Dr. Baillie, Cruickshanks, and Everard Home. The directors of the College sent Hunter a letter of thanks for his help, which he acknowledged in a letter from Leicester Square, Oct. 2nd, 1793, exactly two weeks before he died. This letter long remained a treasured possession of that College, but it has been lost.

Hunter's coach was drawn by a pair of bay stone horses. Jesse Foot, his detractor, saw these horses in Piccadilly returning from Hunter's funeral at St. Martin's Church ; the circumstance recalled to his mind Virgil's account of the war-horse Æthon, in the funeral procession of Young Pallas, shedding tears !

Whales.

Whales are the biggest animals that exist or have existed on the earth, and their skeletons are the most impressive things in the museum. Hunter recognised that whales are land mammals modified to live in the water. He dissected them when he got the opportunity and discovered their semicircular canals. The organ of hearing in these huge mammals is modified in a remarkable manner. The pinna is absent ; the

meatus is narrow and, in some species, nearly obliterated. The tympanic is a shell of bone ; the ossicles—malleus, incus, and

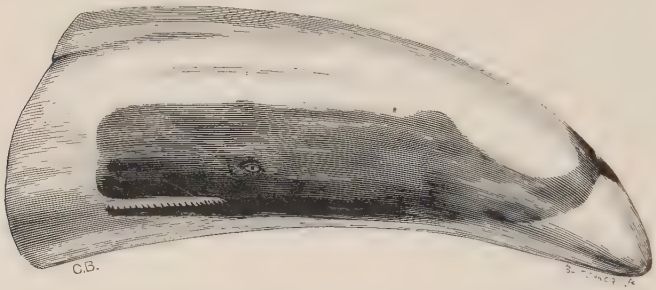

Fig. 9.—Tooth of a whale with a sperm whale etched upon it. (Natural History Museum.)

stapes—are present. The tympanics are so loosely attached to the skull that when the bodies of whales decompose these

Fig. 10.—Tympanic of a whale.

bones fall away. In the Central Pacific, detached tympanics, petrosals, and shark's teeth litter the floor of the ocean. Hunter studied the semicircular canals of fishes before he went

to Belleisle, and it is reasonable to believe that the structure of the internal ear interested him for 30 years.

Lillie, in 1910 and 1915, made some dissections of the internal ear of whales and explains the vestigial character of the external auditory meatus by suggesting that whales hear through their nasal passage, which opens on the top of their heads. The

FIG. 11.—*Orca gladiator.* Though "killer" whales are evil-looking they glide gracefully through the sea impelled by their powerful flukes.

nostrils collect the sound waves to be conducted through the blow-holes to the huge guttural pouches and the Eustachian tubes, thence to the tympanic bullæ, which act as sounding boxes and transmit the sound waves to the chain of ossicles. The shell-like tympanic probably intensifies the sound wave in the water. There is no doubt that whales rely on the sense of hearing and appreciate the pulsations caused by waves striking rocks or the approach of an enemy. These shell-

shaped bones and teeth (Fig. 9) are often kept as curiosities. Here is a tympanic bone (Fig. 10) used as a paper-weight by a lady of fashion, yet it collected sound waves that enabled a mighty whale to move through unfathomable waters with the same certainty that the compass enables mariners to guide ships across the trackless ocean.

Intrepid whalemen who have watched whales in the solitary ocean regard them as timid and inoffensive, with large brown eyes and affectionate in disposition to their young. This

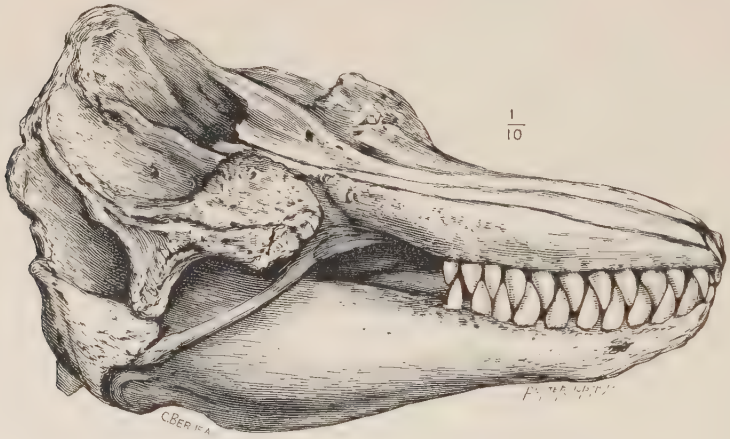

FIG. 12.—Skull of a " killer " whale to show the teeth.

character does not apply to the toothed whale. The " killer " whale has a large dorsal fin and there has been much speculation in regard to its use. Herman Melville in " Moby Dick " states that the flukes of whales are tactile organs of great delicacy. I believe that the median fin of a " killer " is a tactile organ. On watching " killers " rise to the surface, this dorsal fin rises like the periscope of a submarine (Fig. 11).

Captain Wild has described to me tricks of *Orca* worthy of a crocodile. It is not easy for a " killer " to seize a seal on the

edge of the ice, but he swims under it, and rising suddenly, breaks off a piece with the object of dislodging the seal. If the seal retreats crafty *Orca* follows the animal as it lumbers over the ice and breaks off successive pieces in his endeavours to seize the creature. In such tricks the dorsal fin may be a reliable tactile organ like the whiskers of cats and the feelers of cat-fishes. "Killer" whales have formidable teeth (Fig. 12), insatiable appetites, hunt in packs like wolves, and attack the biggest whales.

When Hunter died in 1793, and for many years afterwards, his skeletons of whales were the only examples existing in a museum in England.

Opossums.

Hunter kept opossums at Earl's Court, and about 1790, when he was studying the marsupials which John White brought from New South Wales, he wrote: "There is something in the mode of propagation in the opossum that deviates from all others." He kept many alive, "yet never could get them to breed." The manner in which the fœtus gets into the pouch, after puzzling naturalists for more than a century, has received a simple explanation for opossums and kangaroos. A. Goerling, of Perth, Australia, discovered in 1906 that when the naked fœtus is extruded from the vagina it is blind, but the arms are well developed, the fingers furnished with claws, and it can open and close its hands like the paws of a cat. When extruded the mother licks the birth-membranes and sets the fœtus free, which makes its way

Fig. 13.—Young kangaroo hanging on the teat by its lips. (Museum, Royal College of Surgeons.)

through the fur to the opening of the pouch, enters, finds a teat, and fastens itself on with the powerful lips (Fig. 13). The naked little wanderer requires 30 minutes to make the journey, and travels through the mother's fur moving the arms alternately as in swimming and leaves a track in the fur which lasts some hours. We may believe that in this curious journey it is helped by Jacobson's organ ; in the pouch the little fellow finds protection, warmth, and nourishment, and remains there till its eyes are opened, and when it has donned its fur coat, as many have seen with delight at the Zoo, the little kangaroo looks over the rim of the pouch, and gazes with curiosity on the world at large, and in a way that would have amused John Hunter. C. G. Hartman discovered that the fœtuses of the opossum, *Didelphys virginiana*, find their way into the pouch in the same way as the fœtal kangaroos. (*Anat. Record*, 1920, xix., 251.)

Fossils and Owen.

Belleisle and Portugal had much the same influence on Hunter that South America had on Darwin, especially in relation to geology, and had unexpected consequences, for few suspected his interest in fossils, although they were often sent to him, especially by Jenner. The discovery of the collection of fossils is one of the romances of the Museum. When Richard Owen, in 1826, started to practise as a surgeon near the College, Abernethy, concerned at the neglected condition of the Museum, induced his old pupil to assist in cataloguing it. In this way Owen became acquainted with Clift and obtained access to the collection. A few years later he married Clift's daughter, was gradually weaned from medical practice, and devoted himself to comparative anatomy. While busy with the catalogue he unexpectedly found Hunter's store of fossils, and displayed them in the Museum when it was rearranged in 1837. Startled by

the number and variety of the specimens, he began to work at them seriously. Nothing illustrates more thoroughly the parable of the sower than these fossils. Nearly all this seed sown by Hunter fell on stony ground, but some fell and grew in Owen's fertile brain. He dissected the bodies of animals to enable him to study fossils and become essentially a palæontologist revelling in the reconstruction of extinct animals. The Museum contains reconstructed skeletons of huge ground-sloths; the gigantic armadillo with an "osseous coat in compartments," and a huge bird, the Moa, towering over all of them. Skeletons of sloths and armadilloes, turtles and crocodiles, with ostriches and emus, stand in rows demonstrating the truth of Owen's deductions. When these skeletons were mounted evolution and mammalian descent had not become the stock phrases of zoological zealots. To-day zoologists include extinct as well as living animals in their lists. Before Darwin classification was a mania, since Darwin zoologists persistently endeavour to bridge gaps. Hunter's fossils turned Owen's thoughts to palæontology, and he led men to take an interest in animals, huge and weird, that once moved about the earth and then passed into the twilight and silence of the past.

The Oration.

A man who achieves greatness in any calling inspires others to follow his example. No man retains prominence unless he has impressed others to believe in him and magnify his name. Those who have been closely associated with a masterful teacher and speak well of him are often mockingly called disciples by his contemporaries. Many who during the life-time of a great investigator, or a reformer, were detractors are often loudest in appraising him when dead. When our friends are alive we hesitate to say much about them in their presence—except in after-dinner speeches. As soon as they are dead we are apt, in a paroxysm of sympathy, to overpraise their work. Hunter

was in advance of his time, his contemporaries could not appreciate the value of the work, and some admirers overrate it.

The delivery of the oration is justified. It is necessary to remind men of their benefactors ; even the holiest saints require to have their names preserved by shrines, chantries, cathedrals, or festivals. Are there not Saints' days in the calendar of every church—Protestant, Greek, or Roman ? Æsculapius had two famous sons ; of these Machaon healed injuries, and Podalirius could recognise what was not visible to the eye and tended what could not be healed (Fig. 14). They served with the army in the Trojan war. Podalirius returning from the war was wrecked at Caria, Asia Minor. He had the good luck to cure a princess of falling sickness (probably hysteria), and in consequence acquired a great reputation. The Carians after his death built a temple in his honour and paid him divine honours. This temple has long since disappeared, but his effigy survives on the College seal.

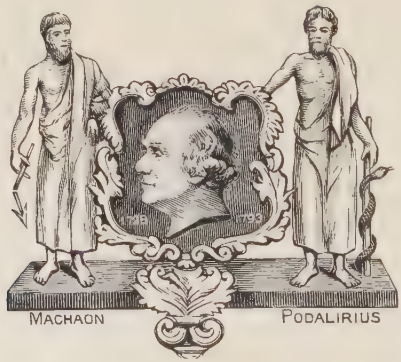

FIG. 14.—Two famous sons of Æsculapius. Machaon healed injuries. Podalirius could recognise what was not visible to the eye, and tended what could not be healed.

The essential work of Hunter's life was the useful specimens he prepared and left for successors. These specimens, safe-

guarded by faithful Clift, catalogued by sagacious Owen, Paget, and such able curators as Flower and Shattock, are now in the care of Keith, who lacks none of Hunter's enthusiasm but totally eclipses him in the art of exposition. The Museum was never in safer custody.

If I could believe the soul of man survives the dissolution of his body, I would believe the spirit of John Hunter haunts the galleries of this wonderful Museum, but I do believe his *influence is a quickening spirit among surgeons to-day.*

II

HUNTER AND PORTUGAL

It is certain that Hunter made observations on natural history and collected specimens whilst in Portugal. He was deeply interested in birds, and in that country had opportunities of seeing British birds making their way to warm southern climates. At that time (1763) there was a keen discussion in England, known among ornithologists, as the swallow-torpidity controversy, concerning the absence of swallows in winter. It was believed by many that these birds became torpid in winter as "the bear, dormouse, lizards, snakes, &c., do." In regard to this affair Hunter wrote: "Swallows of each sort are the same in every part of the world, which shows that they are birds of passage. This is not the case with other birds, that are not birds of passage; for we may observe that countries have their particular species of animals which differ from those of another country in some circumstances." He could speak with confidence in regard to swallows, for he saw swallows at Portalegre. There are persons to-day who believe that swallows hibernate, and there were men who believed that some migratory birds left our atmosphere for that of the moon! The most important results of Hunter's stay in Portugal relate to geology, stimulated by observations made on the plain of Alemtejo.

A Typical Portuguese Town.

As I could find very little information in books regarding these things, I went to Portalegre for the purpose of seeing the

remarkable district which had for Hunter so much interest. It is a typical Portuguese town on the slopes of a steep hill about twenty miles from the Spanish frontier. It has a cathedral and a bishop. Roman remains have been found in the neighbourhood of the town, but there are many remnants of the Moorish occupation, including a ruined citadel. There is a well-preserved Moorish palace, now divided into a shop and a residence. I was allowed to enter and examine the characteristic chimney. The house was clean, neat, and adorned with flowering plants, and appeared a cheerful and comfortable place in which to dwell. Portalegre is like an Eastern town : houses with whitened walls, but grimy inside. Streets narrow, and paved with cobbles, and kept free from garbage by swine. A herd of pigs makes its way through the narrow streets in the early morning, gobbling vegetable remains, such as cabbage leaves and stalks, banana skins, orange peel and apple parings, fragments of bread, and the like. The individuals in this herd of scavengers are distinguished by slits, or punctures, in the ear. The holes vary in size and shape, and resemble punctures made in tickets by railway inspectors. This indicates that the pigs in the herd belong to various proprietors though under the charge of one swineherd. The Alemtejan pig is a stolid animal, its skin is red and thickly covered with bristles, and furnishes excellent ham, but it has some intelligence. When a herd of swine returns from the town, or from a feeding excursion in an olive orchard, or an oak forest, each sow goes to her appointed sty, raises the latch with her snout, opens the door and walks in. Woe betide any sow that makes a mistake and enters the wrong sty.

The slits in the ears of the pigs recall the fact that Hunter at Earl's Court made experiments to determine the effect of extirpating one ovarium upon the number of young produced. He selected two sows of the same colour and size. After removing an ovarium from a sow he cut a slit in one ear in order to distinguish her from the other sow which was kept as a control.

He may have learned this ear-slitting trick in Portugal. Ear-slitting and ear-boring is a very old method ; indeed, it is one of the judgments God gave to Moses—when a man wished to serve his master for ever he should be brought to a doorpost and a hole bored in his ear with an awl. The ear has served as a useful property label for many centuries.

Observations on Geology.

The hill on which Portalegre stands is on a remarkable plateau called Alemtejo (spelt Alentejo in 1763). In an extraordinary tract, published about fifty years after Hunter's death, under the title "Observations and Reflexions on Geology," he refers to the extensive flat tract of land called Alentejo, which shows evident signs of its surface being covered by the sea. The surface of this plateau is strewn with enormous heaps of granite. Hunter discusses the probable mode of origin of the pyramidal heaps of huge stones which are so frequent on the plain. Some of the blocks he notes are pyramidal, "standing on their apex," and "so small is this apex that you could conceive that you could move them." Such fantastic piles, which have been likened to cyclopean masonry, are known in England as "tors." J. W. Gregory describes tors as residual hills left by the denudation of mountain ranges, which have been reduced, first by water when the rainfall was heavier, and then shaped by exposure to sun, wind, and storms in an arid climate.

Hunter had much time and scope for observation and reflection. Although the Alemtejo is a dreary plain and wide tracts of it are covered with "long heath, brown furze, anything," of which honest old Gonzalo would willingly accept an acre in exchange for a thousand furlongs of the sea, it puts on a wonderful appearance in the spring when the flowers appear. Even in December there were gorse, heath, and an occasional cistus, and wild roses in bloom. Most delightful of all, bright blue gentians peered at the sun from among the dry stems of the

cistus bushes. Formerly the Alemtejo was the cornland of Portugal. On the land to-day the wooden plough tipped with iron is used, as in the time of the Moors, and drawn by enormous oxen. In the cultivated tracts wheat, maize, oats, millet, rye, and lupins are grown.

The gardens around farmhouses abound in flowers. Geraniums creep along and over walls ; jasmine and camellias delight the eye. Oranges, figs, and pomegranates not only ripen and delight the eye, but please the palate. Agaves and prickly pears (opuntia) grow side by side and replace the hedgerows of hawthorn and privet so common in England. The fig-marigold (mesembrianthemum) invests railway embankments with a green covering, replacing grass, and makes a delightful show when in full bloom. Even in December a straggling flower shows here and there amid the thick leaves. The politeness of the Alemtejan peasants is delightful, and the men, women, and children are kind to animals.

The Portuguese Peasant.

An idea of the simplicity of the Portuguese peasant may be gathered from an extract of a play by Gil Vicente, the popular satirist and poet of the sixteenth century. It shows that Lusitanian peasants, though revelling in a delightful climate, are as difficult to please as agriculturists in less favoured countries. The peasant complains to the priest that God has a spite against him, and rails in these terms :—

> God sends rain when I don't want it, and when I would have some rain the very stars shine like the sun. Now He swamps the newly-sown fields, or parches everything, or sends cruel wind or snow to kill the flocks, and if I would sue Him for damage done by lightning or thunder, hail or frost, who is to find out His dwelling to summon Him ? He cares for no one and will do as He likes. But in spite, without a farthing to gain by it, sends rain in January and frost in April, and summer heat in February, mists in the month of May, and hail in mid-July.—Aubrey F. G. Bell, *Portugal and the Portuguese.*

Fauna and Flora.

Portugal south of the Tagus is the country of the evergreen oak and the cork-tree. Forests of cork-oaks are interesting features of the Alemtejo. The cork-oak is about 30 feet high, and a forest of these trees may extend over many square miles. The trees themselves with their trunks divested of the thick bark resemble courtiers, dressed in trunk hose, standing on one leg. As the bare tree trunk varies in colour according to the length of time it has been stripped of bark, yellow, red, or purple, the result is a fantastic scene. The trees are stately, not crowded, and the ground under them is covered with wild flowers of which the wood sorrel is conspicuous and almost universal. Black sheep with horns and black goats roam among the trees, guarded by dogs, and each shepherd has a loaded gun, for solitary wolves are not uncommon on the plain. Herds of pigs roam about the forest for acorns, and the swineherd, dressed in sheepskins, is followed by the pigs as sheep follow shepherds. The Alemtejo is the great country for cork and stacks of cork are as common but much bigger than hayricks in rural England. The fertility of the plain, when properly cultivated and watered, is proved by the existence of fruitful vineyards and olive orchards. Visitors to Portugal are charmed with the magnificence of the pines and cypresses.

Conditions of Residence.

Portalegre is 140 miles by rail from Lisbon. In 1763 there were no railways, but there were fairly good roads for horses, mule carts, and diligences. Portuguese mules are excellent. In such circumstances visits to Lisbon could not have been week-end affairs for Hunter. When he did visit Lisbon he could make good use of his time, for the sea on the coast line of Portugal swarms with fishes. The Lisbon fishmarket is furnished with an extraordinary variety of marine forms. Poor folk eat conger,

shark, dog-fishes, and squid. Cuttles and octopods of large size are abundant, and it is amusing to watch the fish women dexterously removing the ink bags and pens from the cuttles. This operation stains their hands and clothes with ink, and they look like printers. Large quantities of squid are used as bait by the fishermen. There is an excellent marine aquarium at Lisbon, named after Vasco da Gama, where it is amusing to watch an irritated cuttle fish discharge its ink and conceal itself in the resulting watery nimbus.

A consideration of the facts connected with Hunter's residence in Portugal may be fairly stated in this way : He added to his experience of gunshot wounds and the administration of a military hospital, but the most important inspiration was an interest in geology (see p. 10).

Note on Swallows in Portugal.

Mr. George Grey Turner, of Newcastle-on-Tyne, gave me a copy of a letter he had acquired written by John Hunter, dated January 15th, 1793. The letter is a good example of Hunter's handwriting, style and bad spelling. His demands for beasts, birds and bees were insatiable. When in Portugal (1763) he was concerned with swallows and cuckoos ; the migration of birds occupied his attention for thirty years, and the name of the latter birds was in Hunter's time spelt cuckows.

Dear Sir,

I was favour'd with your letter of Sep. 91 informing me of two Birds call'd the Habanah being shipd on board the Bull Dog, but unluckly the Birds died on the passage however I consider myself as equally obliged to you for thinking of me and taking so much trouble. I was sorry at the loss of your Insects, after all the trouble of collecting them ; but I hope you will be more successful in future. I mentioned your proposal to Sir Jos^{h} Banks of having a gardener sent out ; he told me he had had a letter or letters to that purpose from you ; therefore I suppose if it was a scheme he approved of he would settle that with you, therefore I drop'd it. There is one thing I want very much to have

settled in natural history, which is the natural history of swallows ; they breed with us in the summer and leave us in the winter, and it is, what becomes of them in our winter ? Now if they are with you in the winter, and if they should breed with you in that season, it would be a proof that they are birds of passage, and upon the same principle you should have many more in the winter than in the summer, as there are 4 or 5 different species in this country in the summer, I should like to have specimens of those that are with you in the winter. I remember seeing swallows in Portugal in the winter, but I can not say what species they were. It would hardly be possible to get orstrschs eggs just going to hatch and to crack the shell and put them into good spirits to preserve them till they come to England. If a foal camell was put into a tub of spirits and sent I should be very glad. Is it possible to get a young tame lion, or indeed any other beast or Bird. If camelions were sent it should be in the spring, as then we could feed them with flys through the summer ; are there any cuckows with you ? We have none in the winter. I want everything respecting the Bee tribe such as wasps with their nests, also Hornets with theirs, etc. They are a very large tribe. I would have sent you a paper I wrote on the aeconomy of the Bees which was published in the Philos. Transactions, but upon enquiry I found it would cost you more than it was worth.

I consider myself as very much obliged to you for your attention to me and I wish I knew how I could return it which would give me pleasure. I hope you keep your health well.

I am Dear
Sir Your much obliged
and Humble servt.
(sgd) JOHN HUNTER.

Jan. 15 1793.

This letter appears in Stephen Paget's life of John Hunter, 1897, and it is there referred to as a letter from South Africa.

III

SURGERY IN EIGHTEENTH CENTURY

(*Spolia Opima. The Presidential Address to the Surgical Section, Royal Society of Medicine, 1918.*)

October 16th should be Lemuria for surgeons ; they need not throw black beans behind them or avoid looking back. Indeed, it is useful to look back ; on this day, 1793, John Hunter died. He recognised the value of meetings arranged for the discussion of matters concerned with the progress of surgery. In 1783, when the lease of his house in Jermyn Street expired, he moved to Leicester Fields and built a museum between the house in Leicester Fields and the house in Castle Street. There were lecture rooms, work rooms, a dissecting-room, and a press room, where his books were printed and published.

In 1785, a society known as the Lyceum Medicum was established under the patronage of John Hunter and Dr. Fordyce. The meetings were held at Hunter's house. Medical cases were discussed by the members, and the more instructive of the additions to the museum were exhibited at the meetings. Hunter slowly mounted the professional ladder, and in the last ten years of his life he had a big and lucrative practice. Passion for scientific work delays a young surgeon when making a practice, but it is a sure rock on which to build, and though practice may come slowly, it comes surely, and persists. Pathology was for Hunter the physiology of disease, but his pathology was mainly morbid anatomy based on the naked-eye study of the dead body. He studied critically the principles underlying the healing of wounds. This is necessary for

surgeons. *If wounds did not heal the art of surgery could not flourish.*

It is difficult to realise, when we bear in mind the ignorance that persisted concerning the causes of disease in the eighteenth century, that surgery could hold its own. The surgeon's time was largely occupied in dealing with injuries, especially cuts, wounds, fractures, and their consequences. Head injuries received much attention. Hernia, a common and serious affection, was carefully studied, and especially the anatomy of hernial regions.

This is true of hydrocele. Astley Cooper, when attending Hunter's lectures, found the town divided in opinion on the best mode of performing operations for its relief. "So great was the difference of opinion among students from different hospitals that it was quite ridiculous to observe their warmth on the subject." *The spirit of the profession on vexed questions remains unchanged.*

The arrest of bleeding takes a foremost place in the work of surgeons. Although Paré acquired in the sixteenth century the simple notion of tying the cut end of an artery to stop bleeding, surgeons are still exercising their minds to find a good ligature material.

It was unreliable ligatures that caused so much difficulty in the operative treatment of popliteal aneurysm. In the eighteenth century the direct operative treatment of popliteal aneurysm was unsuccessful, "a circumstance which led some surgeons of great eminence to prefer amputation of the limb in all cases." Hunter erroneously believed that failure was due to disease of the arterial wall in the vicinity of the aneurysm. He made some experiments on the carotid and on the femoral artery of a dog which led him to believe that the common operation failed because the artery was tied near the sac, and the diseased condition of the arterial wall prevented the proper occlusion of the lumen of the vessel; on the separation of the

ligature bleeding ensued and often killed the patient. This idea led him to tie the femoral at some distance from the sac, where the vessel was healthy. In December, 1785, Hunter tied the femoral artery near the middle of the thigh for the cure of a popliteal aneurysm. The patient, a coachman, recovered. Four ligatures were applied and they were gradually discharged some months after the operation (*London Medical Journal*, 1786, vii, 391). His contemporaries did not get good results from the ligature of an artery remote from the sac. A century later (1886) Sir William Savory reported on the popliteal aneurysms preserved in the London museums; he came to the conclusion that ligature of the femoral artery is not an ideal method of dealing with popliteal aneurysm. He recommended a reconsideration of the question and a return to the pre-Hunterian operation. Lister solved the riddle. The cause of failure was sepsis. As soon as means were devised for making ligature material sterile and reliable, surgeons returned to the ancient method. Some boldly dissected out the sac. In 1888 Matas began to open the sacs of aneurysms and restore the canals of dilated arteries by infolding their walls. He inaugurated a new phase in the treatment of injured and disordered blood-vessels. Since Hunter's death much knowledge of the diseases of arteries has been acquired; he had no idea of the baneful effects of syphilis on their walls. Pathologists slowly realised that in this extraordinary disease the inner and middle coats of arteries soften, and yielding to the pressure of the blood form dilatations—aneurysms. Veterinarians have long known that aneurysms of the anterior mesenteric artery of the horse, and the ass, are due to injuries inflicted on the wall of this vessel by the palisade worm, *Strongylus armatus*. The sexless larvæ of this worm enter the blood stream and damage the walls of the artery by anchoring on the internal coat by their teeth. Verminous aneurysms are well known especially in relation to embolic colic in horses. Later it was discovered that emboli

associated with septic endocarditis swarm with streptococci, and such clots, arrested in arteries, induce local infection of the arterial wall inducing the formation of aneurysms. Such are known as embolic aneurysms. Then came Schaudinn's brilliant discovery of the cause of syphilis, a microscopic parasite, the *Spirochaeta pallida*, a trypanosome. The inner and middle coats of the arteries are its favourite haunts. Then truly the eyes of surgeons were opened and the relation of syphilis to aneurysms was revealed.

Operative Surgery in the Eighteenth Century.

Operations in Hunter's time consisted of bleeding, opening abscesses, removing pieces of dead bone, tapping for dropsy, releasing strangulated hernias, trephining the skull for cranial injury, cutting for stone in the bladder, castration, Cæsarean section, removing pendulous tumours and cancerous breasts, and amputating limbs. Hunter was also especially interested in transplanting teeth.

The mortality of operations from post-operative sepsis was enormous. As late as the middle of the nineteenth century the operating theatre in one London hospital was over the post-mortem room, and seams in the floor "opened wide." The suffering of patients during operations was indescribable. Surgeons in those days must have been men of rare courage to practise an art requiring so much self-control. Some were very dextrous. The description of an amputation performed by Liston in pre-anæsthetic days gives a good idea of surgical dexterity :

> He took a formidable knife, and, having a scalpel in readiness, thrust the knife pointwise through the thigh, and, cutting downwards and towards the surface, in a moment completed the flap. A second and similar cut, below the femur, made another flap, the two incisions were united at the sides, the scalpel passed rapidly round the bone, the muscles *en masse* drawn up, the saw taken . . . and the limb fell to

the ground. The rapidity was truly miraculous . . . the limb was on and off in a wonderfully short space of time ; and this operation demonstrated the manual dexterity which practice will enable a man to acquire, whether it be in amputating a limb or picking a pocket.

The post-operative sufferings of patients were often dreadful, and the risks great. There is a specimen in the Middlesex Hospital Museum which I often look at as exemplifying these risks. It is a portion of the femur with an ivory peg in it. Its history is very instructive. A middle-aged man, the captain of a whaler, broke his thigh in the South Seas. The sailors put the leg in splints. Some months afterwards he was admitted into King's College Hospital with the fracture ununited. Sir William Fergusson rubbed the fragments together ; subsequently he scarified them subcutaneously, and later inserted an ivory peg between them. No union followed, and Sir William amputated the limb. Secondary bleeding occurred after the flaps had partially healed, for which Mr. J. W. Hulke tied the superficial femoral artery. An aneurysm formed at the seat of ligature. The patient died a few months later. The specimen is not only instructive, but it is of historical interest.

Surgeons vainly imagined in the dawn of the twentieth century that they had seen the last of post-operative sepsis. Sir Charles Bell's water-colour sketches, recently exhibited in the museum of the Royal College of Surgeons, England, are vivid pictures of septic fungating gunshot wounds incurred at Waterloo. The present war has given surgeons an opportunity of testing their accuracy and witnessing similar horrors.

IV

THE SURGEON OF THE FUTURE

(*The Address on Surgery delivered at the Meeting of the British Medical Association at Aberdeen, August 1st*, 1914.)

The art of surgery is probably as ancient as the art of war, and is practised by warlike savages who have never been influenced by civilisation. The antagonistic callings of the soldier and the surgeon have been markedly modified by the progress of science. It is believed by many that the ingenuity exercised in the invention of methods for destroying life will make war impossible, and the discovery of the causes of diseases and the perfection of preventive medicine will render physicians and surgeons unnecessary. The belief in each instance is futile. Soldiers and surgeons will be required as long as civilisation endures ; but their methods have undergone great changes and greater are impending. Gunpowder revolutionised warfare ; the discovery of anæsthetics and the invention of the microscope completely changed surgical methods.

Surgery and the Discovery of Anæsthetics.

The enormous impetus which the discovery of anæsthetics gave to surgery threatened to extinguish it as an art, for post-operative suppuration and pyæmia became endemic plagues in all populous cities where the surgeon plied his craft. It was on this unfavourable flood that some of the most notable ventures of modern surgery were launched, but their progress was slow.

Traditions and methods die hard! A famous surgeon told me that when he began to perform operations under chloroform an old pupil of Guy's Hospital came in to see a leg amputated under the new conditions. When the surgeon pointed out the merciful nature of anæsthetic sleep and the change it had wrought in the methods of removing limbs, the old fellow sighed, and said he had a fancy for the old ways, and liked to see some blood and sawdust about! Sir William Fergusson delivered some lectures on the progress of anatomy and surgery at the Royal College of Surgeons of England in 1855, and described operations performed at that date in London in this rough-and-ready style. You will acquit me of exaggeration when I state that the arena of an operating theatre in the first half of the nineteenth century smacked of the bull ring, and the board in the old operating theatre, that bore a notice regarding the reservation of the arena for the surgeons and the first two rows of stalls for privileged spectators, recalls the notices *Sol* and *Sombra* in the Plaza de Toros.

In the early stage of a great discovery few men perceive its significance. When anæsthesia began to make progress, although surgeons recognised its importance, many years elapsed before it was fully utilised. Chloroform had been in constant use for operations before its usefulness in the reduction of dislocations was recognised. Operating theatres had iron bars and racks fixed to the walls and ring-bolts let into the floor for the attachment of cords and pulleys employed in the forcible reduction of dislocated shoulders and hips. In the Middlesex Hospital the dislocation fixtures and tackling were abolished with the old operating theatre in 1895. To-day a dislocated hip is reduced with the help of chloroform without pulleys, almost in the twinkling of an eye. When done expertly it resembles a conjuring trick. Let me briefly describe an actual case to show what harm sometimes followed the use of pulleys in reducing a dislocated hip. In 1889 the chief officer of a ship

had his hip dislocated by a derrick-boom falling upon him during a voyage in the Atlantic Ocean. The captain attempted to reduce it. As a preliminary the patient drank half a bottle of brandy and fifty drops of laudanum. Being drunk he was fastened by a perineal band to a ring-bolt on the deck, and ten seamen, under the superintendence of the captain, hauled steadily on the leg. Their efforts were unavailing. Four days later the ship touched the Canary Isles, and the officer was sent ashore ; the head of the thigh bone was promptly reduced by a surgeon under chloroform. On recovering the patient was unable to walk without pain. When the limb was extended he felt a pricking pain down the back of the thigh to the knee, then it divided, and " one stream of painful sensations " ran down the back of the leg and the other along the front of the leg to the toes, and the sailor found it hard to kick against the pricks. I saw him in London, and came to the opinion that the efforts of his shipmates had broken the rim of the acetabulum and a spicule of bone interfered with the great sciatic nerve. By means of an incision in the buttock the nerve was exposed as it issues from the great sciatic foramen. I found a hook-shaped piece of bone on the rim of the acetabulum in such a position that its sharp end pricked the nerve when the limb was extended. This piece of bone was removed. The officer recovered, and reported himself in good health twenty years afterwards.

The utility of chloroform in the diagnosis of hysterical contractures, phantom tumours and spurious pregnancy was its last merit to be appreciated. The surgery of the viscera is one of the remarkable extensions that followed the introduction of anæsthetics. Abdominal organs such as the spleen and omentum were removed when extruded through accidental rents made by knives, spears, swords, scythes, sickles, chariot wheels, or similar forms of violence, and extruded intestines were returned with success centuries before the discovery of ether and chloroform. Cæsarean section was successfully per-

formed in Roman times, and many a child, to use Shakespeare's phrase, "was from his mother's womb untimely ripp'd." This form of delivery has been effected by midwives and butchers; by a patient on herself, and by the horn of a mad bull; in some instances mother and child survived. The success that followed this inartistic mode of delivery is instructive; forty years ago Cæsarean section had an astounding mortality when performed by surgeons, whilst the spayer and gelder carried out his calling with almost invariable success. Lister unravelled the riddle. To-day wounds made and closed in the course of a surgical operation unite with a certainty that ceases to attract attention. Surgeons rarely pause to think on what would happen if surgical wounds failed to heal. In the pioneer days of abdominal surgery the incisions often failed to unite, and such patients frequently died. I shall later on place facts before you to show that failure of intestinal wounds to unite is one cause of the high mortality following operations for cancer of the colon. Union of healthy intestine takes place quickly and perfectly.

New Diseases.

We marvel to-day at the frequency of the disease called appendicitis that became endemic in great centres of civilisation in the last quarter of the nineteenth century. This disease occurred sporadically, and had been known as perityphlitis and iliac abscess for many years, but the cause of the present epidemic has not been discovered by pathologists or bacteriologists. A study of the history of diseases shows that they wax and wane. In the fourteenth century lepers were common, and leper houses were as numerous in Europe and the British Isles as lunatic asylums to-day. Leprosy lingered longest in Scotland. I thought it probable, reflecting on the prevalence of leprosy in Iceland and Norway, that there may be some lepers in the northern islands of Scotland. I have been assured on reliable authority that there is no leprosy in the Orkneys.

Whilst pondering on the absence of this disease in Britain, doubts arose in my mind on reading in Lord Strathcona's will (*The Times*, May 14th, 1914) a bequest of £5,000 to the Right Hon. John Burns for a home for fifty lepers in the United Kingdom, none of the sum to be expended upon lepers coming into the kingdom.

In Europe, generally, leprosy diminished greatly without any recognised cause in the fifteenth century, but its decline was coincident with a great increase in syphilis. One disease tramples out another. In the vegetable world, grass and what we call weeds and the Bible tares choke the nobler plants. When from accidental causes weeds are held in check, the suppressed plants revive and flourish again. It was a great discovery to detect the part played by insects as unconscious pimps in the fertilisation of flowers. No one can doubt that the disappearance of many species of flowering plants and variations in the abundance or the scarcity of particular species of flowering plants depend not merely on favouring conditions of weather, but on the abundance or scarcity of the insects that act as vectors of the precious pollen from the flowers of one plant to the flowers of another of the same species. Diseases supply parallels. To-day we are staggered by the important observations that many infections are conveyed from man to man, man to beast, and from beast to man by insect agency. Flies act as vectors of the parasites of sleeping sickness, gnats spread filaria, malaria, and yellow fever ; fleas infect man with plague ; and bugs can convey the leprosy bacillus.

The famous plagues of Egypt, fraught with such important consequences to the Israelites, were intensified by flies. When the narrative is considered in the light of modern knowledge it is a fair inference that the dust storm which fouled the Nile water and rendered it undrinkable killed the fishes and caused the frogs to take refuge on the land. The dead fishes and frogs provided breeding places for flies, and they were hatched out in myriads.

During the last decade the fly has come to be regarded as a conveyor of disease, and the indictment is very strong. The biting fly conveys parasites in its proboscis, and the common non-biting fly carries on its body, legs and wings the infective agents of typhoid fever, tuberculosis, ophthalmia, and perhaps small-pox. The sequence of the Mosaic visitations is significant ; the plague of flies was followed by a murrain among beasts and boils and blains on the Egyptians. The death of the children was the last plague, and it is the last to be explained by modern science. Dr. E. H. Ross was medical officer in Cairo in 1909. He tells us the spring of that year was ushered in by a heat wave on May 1st, and the temperature rose to 102° F. in the shade. Fourteen days later the greatest plague of flies ever remembered appeared in the city. Food, milk, and fruit were contaminated by them. In two months 3,000 children under five years succumbed to enteritis—a disease due to infection. It is not an unreasonable assumption that the death of the Egyptian children, which induced Pharaoh to let the children of Israel go, was due to an epidemic of infantile enteritis spread by an enormous swarm of " divers sorts of flies."

One of the greatest plagues which troubled surgeons and destroyed millions of lives is known as suppuration or pyosis ; it was spread widely by surgeons. When Pasteur discovered the cause of fermentation and Lister gave this discovery a practical application in the daily work of the surgeon, it was not suspected for many years that the most dangerous items in a surgical operation were the infected instruments and the fingers of the surgeon. The importance of this observation cannot be over-estimated ; surgeons admit its truth by wearing sterilised rubber gloves when performing operations.

The Microscope in Surgery.

It is usual to ascribe the remarkable progress of surgery to the discovery of anæsthesia and the perfection of methods designed

to prevent wound infection, but we must not forget the most important was the invention of the microscope ; without its assistance the minute bodies which effect such great changes in organic and inorganic nature, and cause so many varieties of infective disease in animals and plants, would have remained not only hidden but unsuspected. This important instrument of research, perfected by earnest workers mocked at as " brass and glass men," is now indispensable in clinical research. Every improvement in the construction of the microscope has led to an increase in knowledge of the cause of disease. It has also become a means of popular instruction and amusment. Even embryologic processes are displayed to interested pleasure seekers on kinematographic films in " picture palaces," and school children are instructed in physiology, including the microscopic features of the blood. The numerical estimation of blood corpuscles is a regular exercise for the clinical clerk, and corpuscles are scrutinised in the laboratory by experts with microscopes as diligently as physicists examine the solar disc with telescopes for sunspots. Specks in the white and in the red corpuscles, barely visible to the highest powers of the microscope, may have more influence for evil on the health of a community than a sunspot big enough to be visible to the naked eye exercises on the weather.

Derangements of the functions of blood-forming organs, especially the red marrow, and the significance of an excessive production of leucocytes have come to be so thoroughly appreciated by surgeons that, under certain conditions, an excessive proportion of white corpuscles in the blood is a more emphatic bar to a surgical operation than sugar in the urine. It is in this direction that the increase of pathological knowledge, especially the form of it called clinical pathology, will influence operative surgery in the future. The light microscopic studies of the blood-throw on leukæmia acts as a danger signal to the surgeon when contemplating the removal of an enlarged spleen.

The extirpation of a leukæmic spleen is always followed by death, and this experience is crystallised in practice, for an abdominal tumour resembling a spleen always suggests a blood-count.

The Influence of Chemotherapy on the Surgery of the Central Nervous System.

Disease was formerly regarded as something that entered the body, and the idea of evil spirits or devils entering men and women led, even before the dawn of Christianity, to surgical practice consistent with such belief, for there is evidence that the skulls of epileptics were trephined to afford incarcerated evil spirits a chance of escape. Fifty years ago our knowledge regarding the physical condition of the brain and spinal cord was of an elementary kind. It was the custom to teach that the cerebro-spinal fluid served as a waterbed for the brain in order to preserve it from harmful concussions. In my student days this teleological explanation tickled my fancy, and I suggested to the lecturer on anatomy when he waxed enthusiastic, after the style of Hilton, on this wise precaution of nature, that the explanation was absurd, for the relative bulk of brain and cerebro-spinal fluid resembled an ironclad in a duck pond. Now cerebro-spinal fluid is used as a medium for inducing temporary paraplegic analgesia—a method of conscious anæsthesia of great advantage to the surgeon when he is called upon to operate in conditions where a general anæsthetic would be attended with unusual risks. The diagnostic importance of cerebro-spinal fluid obtained by lumbar puncture is not only great, but its utility is increasing. Examination of samples of the cerebro-spinal fluid obtained by tapping the spinal theca is a routine in diagnosis.

Flexner's demonstrations, that the olfactory nerves are routes by which the microbes of influenza and cerebro-spinal

fever infect the central nervous system, add a new interest to the physiology of those remarkable secretory organs in the brain called choroid plexuses. In discussing influenzal meningitis he tells us that the fluid secreted by the choroid plexuses in infected monkeys contains an antiserum which escapes by the meningeal veins, and it may become possible to arrest the development of bacilli in the blood by means of compounds injected into the cerebro-spinal fluid. Here is a method of specific therapy unsuspected in our wildest dreams : Science transforming the cerebro-spinal fluid into a pool of Bethesda ! Enterprising surgeons are now devising methods by which they can " trouble " the pool to the best advantage. No one can doubt that bacteriologists are, in their methods as ingenious as surgeons. Crowe and Cushing ascertained that urotropin (hexamethylenamin) given by the mouth is excreted into the cerebro-spinal fluid and inhibits the growth of pyogenic bacteria. Surgeons turn this observation into practical account ; it is now the custom to administer urotropin internally two or three days before an operation on the brain or spinal cord, and continuing it for a few days afterwards. Post-operative meningitis occurs occasionally in spite of it !

Orr and Rows have found that micro-organisms use neural lymphatics as routes for infecting the cord. Thus a bedsore, or any septic area of the skin, can lead to an infection of the spinal cord at a spot corresponding to the roots of origin of the implicated nerves. This will intensify the interest of surgeons in neuritis complicating septic lesions. The brilliant demonstrations that spirochætes use the lymphatics of nerves as avenues for invading the spinal cord will modify the treatment of syphilitic diseases of the cord. Intrathecal injections of salvarsan, in common with all arsenical compounds, irritate the spinal cord. To overcome this difficulty salvarsanised serum obtained from the patient is injected into his cerebro-spinal fluid and tolerated. This is a good example of practical ingenuity.

The results of surgical enterprise on cerebral tumours are unsatisfactory ; the mortality is great and the condition of the survivors in many instances sad. The indefiniteness of gliomatous formations makes them extremely unfavourable for operation, to say nothing of the difficulty in localising cerebral tumours in non-motor areas. It is probable that compounds will be discovered that can be injected into the cerebro-spinal fluid and cause gliomas to shrivel in the same way that gummas disappear under potassium iodide, mercury or salvarsan, and thus abolish some of the most unpromising operations of modern surgery.

Surgical Gambling with Malignant Disease.

Investigations of the minute structure of morbid growths have been mainly useful in separating the so-called benign tumours from those which inevitably destroy life. Thirty years ago the two groups were regarded as distinct. It is true that type forms can be distinguished as innocent or malignant, but each genus of the so-called innocent group, with the exception of lipomas, contains species in which the histological features of innocency shade away into those indicating malignancy. This is a matter of great importance when a declaration of malignancy entails the sacrifice of an organ or a limb. The horror patients entertain of malignant disease and the stigma they think it imprints on the family reputation lead to willing submission when the surgeon offers operative treatment. It is an impression deeply ingrained in the profession that the presence of malignant disease justifies an operation, however extensive or dangerous, for its relief. Let us satisfy ourselves that surgical gambling with malignant disease is justified. There are two organs in the body often the seat of cancer and often attacked by surgeons—the uterus and colon—in connection with which this question may be fairly considered.

The results of removal of the uterus for cancer in its neck are by no means uniform even when the conditions are apparently similar. The microscopic features of cancerous growths do not help in explaining variations in the clinical course of the disease. There are intrinsic and extrinsic factors concerned in estimating the malignancy of uterine cancer which have only recently been appreciated. Our predecessors in the art of surgery recognised a remarkable alteration in the appearance of patients the subjects of advanced malignant disease, which they expressed by the phrase "cancerous cachexia." This "bad habit" of body has no special relation to cancer; it is due to the entrance into the circulating blood of toxic substances secreted by the bacteria and cocci which colonise cancerous growths in exposed situations. The relation of bacteria to cancer is a matter of first-rate importance to the surgeon, and influences his work very markedly. I find, as a rule, that non-ulcerating cancers of the breast are sterile. Cancer of the tongue usually swarms with streptococci, and the neck of the uterus when cancerous is colonised by staphylococci or streptococci and the coli group. This led me to make bacteriological investigations of the necks of cancerous uteri before undertaking their removal; I quickly found that the fate of a patient submitted to operation for this disease depends not so much on the skill of the surgeon as on the nature of the infecting micro-organism. Many patients submitted to hysterectomy for cancer of the neck of the uterus die within a few days of the operation from septic peritonitis, pulmonary embolism, or acute bacteriæmia if the cancerous tissues are colonised by streptococci.

In the general hospitals of London during the year 1912 the mortality of radical hysterectomy for cancer of the neck of the uterus varied from 10 to 48 per cent. This forms a striking contrast to hysterectomy for fibroids of the uterus, for the mortality of this operation in the general hospitals of London is about 2 per cent., the difference being almost entirely due to

the presence of bacteria and cocci in the cancerous tissues. It cannot be too emphatically stated that the virulence of cancer, as a rule, depends on its septicity, and cancers in exposed situations are rapidly destroyed by bacteria.

Sepsis in Relation to Cancer of the Large Intestine.

The relationship of sepsis and cancer is an important matter for the surgeon. During the last ten years there has been great activity in developing radical measures for the treatment of cancer of the large intestine. The results are not gratifying. Resections of the cæcum, or portions of the colon, are attended with a high rate of mortality, and of those who survive operation early recurrence or dissemination is the rule. Surgeons know this, and in order to improve the results of operative treatment painstaking investigations have been made on the distribution of the blood and lymph vessels of the colon. In spite of much admirable work and surgical enterprise, cancer of the large intestine is as opprobrious to the surgeon as hysterectomy for cancer of the neck of the uterus to the gynæcologist, and for the same reason—sepsis. The mortality of radical operations for cancer of the cæcum and colon in London during 1912 was 30 per cent. In the London Hospital during the years 1901–11 resection of cancerous portions of the large bowel was performed on ninety-five patients; forty-nine recovered and forty-six died. (Sir Frederic Eve.) In these days of boastful surgery this may be called a superlative death rate.

The radical method of dealing with cancer of the colon consists in free resection of the cancerous portion in favourable cases; this requires a complicated operation for the reunion of the bowel, entailing a sutural junction that must be not only watertight but gastight. One of the first requisites for immediate union is the absence of pyogenic bacteria. In operations for intestinal anastomosis success depends on early and firm

union of the apposed surfaces of the bowel. There is nothing more amazing in relation to the healing of wounds than the rapidity with which peritoneal surfaces join when they are carefully sewn together with sterile sutures. In regions of the gastro-intestinal tract free from pyogenic bacteria union occurs after surgical operations safely and quickly; thus a gastro-jejunostomy in the hands of competent surgeons is devoid of risk from septic peritonitis. How different the picture for radical operations performed for cancer of the colon; septic peritonitis destroys the lives of at least 30 per cent. of those who submit to them. Death is due to septic peritonitis from infection during operation, leakage at the junctions, or failure of union due to the colon bacillus and its congeners.

Cancer of the colon is an extremely insidious disease; in the early stages it is symptomless until it becomes septic or obstructs the flow of fæces, then the patient complains of pain. When cancer becomes septic it sloughs and bleeds. Infected cancer impairs the patient's health because the toxins brewed by the schizomycetes colonising it enter the circulation. Colic cancer sometimes leads to abscess when it is infected by the coli group. The frequency with which visceral cancer mimics inflammatory conditions and misleads physicians and surgeons alike is due to sepsis. The appreciation of the causes of failure in the surgical treatment of colic cancer should exercise some influence for good. Statistics indicate that the risks of operations performed for cancer of the colon are as great as for the operations of general surgery in pre-Listerian days, with this difference—the mortality of that period was due to sepsis from infection of the wound that often arose from the use of dirty sponges, instruments, sutures, and the septic fingers of the surgeon and assistants. In operations on cancerous viscera the diseased tissues are already infected, and taint the fingers and instruments of the surgeon, hence the danger of such operations.

Surgical Coquetry.

It is by no means uncommon to see surgeons clad in sterilised overalls, gloves, caps, masks, and topboots, resecting a cancerous segment of colon swarming with pyogenic micro-organisms. This can only be described as surgical coquetry. Some of our methods for destroying bacteria in the course of an operation are almost as clumsy as attempts to kill fleas with bludgeons.

In order to improve the results of operations for visceral cancer means must be devised for sterilising them, or a specific remedy found for cancer. There are indications that both methods will be available. Cancerous organs are sometimes submitted to the action of radium as a preliminary to operation. and histological examinations of malignant tumours affected by radium emanations show that the gamma rays find distinctions in tissue cells imperceptible to the microscope. We need a compound which can be introduced into the circulation to destroy the streptococcus and its kind. This is no idle dream. Huxley suggested that it would become possible in view of the discoveries in therapeutics "to introduce into the economy a molecular mechanism which, like a very cunningly contrived torpedo, shall find its way to some particular group of living elements, and cause an explosion among them, leaving the rest untouched." This sounded fantastical in 1881, but Ehrlich has discovered "molecular mechanisms" more subtle. There are drugs (organotropic) which injuriously affect the organs of the body and fasten on them like aniline staining reagents cling to special tissues. He speaks of compounds that injure the intestinal tract of mice, and they die from profuse diarrhœa. Sometimes the red blood corpuscles are attacked, and the animal dies from severe anæmia. Curious drug affinities occur in the central nervous system; in mice the vestibular nerve is attacked, and they gyrate like Japanese waltzing mice.

The derivatives of phenylarsin acid attack the optic nerve, and large doses of atoxyl produce blindness.

What surgeons urgently need is a molecular compound which will either kill the bacteria and cocci that colonise cancer, or neutralise their harmful toxins in the same way that salvarsan renders the spirochætes inert without destroying the organs or tissues of their host.

The Surgeon of the Future.

In pre-Listerian days the path to surgery lay through the dissecting-room. A thorough practical knowledge of the anatomy of man was and is indispensable to a sound surgeon. Many surgeons whose names are prominent in the history of surgery—from John Hunter to Fergusson—taught anatomy by dissection. Surgeons no longer act as demonstrators of anatomy or conduct post-mortem examinations; the principles of antiseptic surgery forbid such occupations. The practical training in the dissecting-room and post-mortem room teaches men something they cannot learn from books—the appreciation of tissue; this means, in plain terms, the power to recognise organs and tissues, normal and abnormal, at sight or by touch in the course of an operation.

Surgeons are of two types: they are either craftsmen or biologists. The surgical craftsman invents variations in technique—metal plates, wires, and screws for bones; or fancy methods of suturing wounds. Some expend their ingenuity on surgical cutlery and improve the knives and needles. The utility of a simple tool such as the clip forceps is inestimable. In spite of much ingenuity among surgeons an ideal ligature material awaits discovery. Clever contrivances like the laryngoscope and bronchoscope have revolutionised special branches of surgery. Another useful instrument, the œsophagoscope, requires for its successful use a surgeon with the instincts of the sword-swallower and the eye of a hawk. With the aid of

a cystoscope the surgeon can watch the actual extrusion of a calculus through the vesical orifice of a ureter into the bladder.

The biological surgeon studies pathology in its broadest aspects and investigates, in the laboratory, problems of morbid anatomy and bacteriology. The diagnostic value of reports issued from the laboratory by the pathologist and the bacteriologist to be of value must be estimated with the help of clinical experience. If the surgeon has had no experience in bacteriological methods he must accept the reports from the laboratory with the hopefulness of a patient swallowing physic compounded from a prescription he does not understand and which he is often unable to read. The training of surgeons in clinical pathology is of great importance, and it requires little foresight to recognise that for men ambitious to attain high places in surgery the high road lies through the pathological institute.

Morbid histology has been and still is of great use in classification, diagnosis, and prognosis of morbid growths ; for a knowledge of their cause new methods are required. For these we fix our attention on the men along the sky line—bacteriologists, experimental physiologists, physiological chemists and physicists ; the future lies with them. As it is of the utmost importance that surgeons shall have a practical knowledge of clinical pathology, it becomes essential to bring the wards, operating theatres, and laboratories into the closest intimacy. From this union of workers means will be found for curing diseased organs by chemiotherapy rather than by extirpating them. Until the right compound for curing cancer has been discovered surgeons will continue to excise cancerous viscera, and this makes it more necessary to discover means for ridding cancer of pyogenic bacteria.

The skill, ability, and dexterity with which surgeons remove a kidney, the uterus, or perform extensive resection of the intestines, great and small, can be witnessed almost daily in the splendid hospitals of large cities, but surgical effort is handi-

capped by streptococci and the coli group, which are very resistant to chemiotherapy. There is something fascinating in submitting septic morbid growths to what Ehrlich picturesquely terms a "bacteriological siege." Our difficulty is to destroy these seeds of disease without serious damage to the organs and the delicate tissues in which they flourish. The antiseptic solutions employed against bacteria are powerful cell-poisons. We need therapeutic agents which destroy parasites, but do not kill the tissues of the host. Acute minds are busy with these problems, and surgeons may hope to remove visceral cancer with no more risks than attend gastrojejunostomy or hysterectomy for fibroids.

The magical effects of salvarsan on the lesions of syphilis, acute and chronic, lead us to hope that this compound will assist in the elimination of cancer of the mouth and tongue, for in these situations cancer is often engrafted on chronic syphilitic lesions. It is reasonable to believe that within a few years surgeons will notice a marked decrease in the number of men with cancer of the lips, gum, tongue, and pharynx, and of women with cancer of the vulva. The extinction of these forms of cancer will relieve surgeons of some of the most distressing and unsatisfactory operations they are called upon to perform.

In regard to the cure of malignant disease, there is most hope in chemotherapy. In detecting the cause of cancer histology has proved a false dawn, but, like that peculiar light which precedes the dawn in the tropics, it is very fascinating. Who can tell how long we shall have to wait for the real dawn! We need not despair; the zeal, enthusiasm, and acumen of laboratory workers fill us with the hope that the ideal of all practitioners of medicine and surgery is attainable—the control of all forms of infective disease.

V

SCIENCE AND SURGERY

(*The Inaugural Address at the Meeting of the Association of Surgeons of Great Britain and Ireland, May 13th*, 1920.)

Surgery is probably an ancient occupation like that of the gardener, cobbler, or potter. The gardener required few tools —a knife, axe, spade, and basket; also bast and fibre. The potter required fewer, and the astonishing results he produced with his fingers on a lump of soft clay, with the aid of a wheel made a deep impression on the minds of thoughtful men. The potter's productions resembled creative acts, and this idea is emblazoned in the Jewish and Christian conceptions of the creation of man—God made man in His own image. Gods fashioned by the potter, *Dii fictiles*, were regarded with reverence by the Romans. When the potter acquired the art of firing and glazing his clay productions, he made them imperishable. Surgeons work on very perishable material and for their own time, for manual dexterity appeals only to witnesses.

Surgery is allied to cobblery. The tools of the surgeon and the cobbler are of three kinds: cutlery—knives and shears; implements for aiding manipulation—pincers and a last; and means for joining parts—threads, bristles, awls, or needles. Replace the last by a saw, and the tool-bag for each is complete. Denoted by their modern names—scalpel, scissors, saw, forceps, needles, sutures, and ligatures—such a set of tools is sufficient for 75 per cent. of the operations performed by surgeons.

Good craftsmen produce excellent results with simple tools.

Modern surgical instruments are excellent in shape and quality, but at the time of the destruction of Pompeii, 79 B.C., tools used by surgeons were as gross as those of farriers and tinkers. The Pompeian mural painting, preserved in the National Museum, Naples, shows Iapyx attempting to remove the head of the dart from the thigh of Æneas. The wounded hero, supported by his faithful friends, Mnestheus and Achates, leans on his long spear; Ascanius, his son, weeps as the surgeon, with coarse forceps, tugs vainly at the dart. Venus, with her face muffled in a thin cloud, pitying but triumphant, supplies the tincture that releases the missile, heals the wound, and enables Æneas to fight again (Fig. 15, p. 61). The museum contains a pair of surgical forceps, found at Pompeii, identical in shape and size with the forceps in the hand of Iapyx.

Omphalitis.

Surgery should interest all. Everybody who survives birth is subject to a simple operation, omphalotomy, tying the navel cord. This simple act requires a piece of string and something with which to divide the cord. In the absence of knife, shears, a potsherd, or a piece of sharp flint, it may be bitten through, as in the case of animals. Surgery had its beginnings in such simple operations as omphalotomy, circumcision, and the sewing-up of wounds, and it remained a simple craft for centuries. The prime duty of the surgeon was the treatment of wounds and injuries: this involved the use of threads and needles, and implements for the reduction of dislocations.

Prehistoric midwives probably used the same kind of ligature material that surgeons use to-day: fibre from plants, especially flax; tendon, catgut—in use for musical instruments—could scarcely escape employment as string; and silk. Though midwives tied the cord with string, surgeons did not appreciate its value for tying a cut artery until the sixteenth century, and it

was in the latter part of the nineteenth that they learned the dangers attending the use of dirty threads for such purposes. In my early days (1878) surgeons waxed the threads like cobblers with the hope of avoiding sepsis. The use of thread for tying the navel cord has had a dreadful post-operative mortality from general sepsis, the umbilical vein serving as the channel of infection. The literature relating to omphalitis is extensive: Miller's account of the appalling infant mortality in the Moscow foundling hospitals, published in 1888, and the well-known "scourge of St. Kilda" are examples of the deadly nature of this kind of wound infection. Omphalitis has attracted much attention during the last thirty years, and now strict surgical measures prevail in the birth-room, a new literature has sprung up relating to it, and as many methods are advocated for amputating the placenta as for removing a pile.

Endeavours to ascertain the cause of sepsis exercised the minds of the greatest surgeons. Seventy years ago the riddle seemed as insoluble as the cause of cancer appears to-day. Although the preparation of alcoholic beverages and bread by fermentation has been practised from remote periods, and festering wounds were as familiar as fermentation, and the rotting of dead plants and animals even more familiar, it was left to Pasteur and Lister to prove that these apparently dissimilar processes—fermentation, suppuration, and decay—are due to minute living organisms.

Particulate Causes of Disease.

The microscope enabled men to discover particulate causes of disease and to discern the manner in which they are distributed in the body. When we watch with a microscope the circulation of the blood in the web of a frog's foot, the passage of the red corpuscles through the capillaries is as exciting as our first glimpse with a telescope of Jupiter's moons or the belt of Saturn. Who, fifty years ago, on seeing the corpuscles whirling

in the blood-stream, could imagine that in a few decades improvement in technique would enable pathologists to write of the flora and fauna of the blood with the same familiarity as that with which botanists and zoologists discuss the plants and animals special to a continent ?

The distribution of minute parasites in the blood is instructive ; some sport in the liquor sanguinis, some select the white corpuscles, and some the red. Grosser parasites use the blood-stream for transport to favourite sites for multiplication, and some permeate the walls of the arteries. Extreme minuteness to the microscopist is like enormous distances for the astronomer. One talks confidently in micro-millimetres, and the other in millions of miles. Who shall contradict them with equal confidence ?

The Royal College of Physicians celebrates yearly the discovery of the circulation of the blood. The discovery of the lymphatic system was almost as important. Asellius found the lacteals by accident in 1622. He opened a living dog to investigate the action of the diaphragm, saw the lacteals filled with chyle, and recognised their nature. His enthusiasm would have led him to open living men as he had dogs, but he checked this inclination (Cruikshank). Now surgeons daily open living men and interfere with the stomach ; in the course of such operations they can often show to the students lacteals turgid and white with chyle (especially if the patient has swallowed some milk two hours before operation), it is a common demonstration, and thus repeat the original observation of Asellius.

Cruikshank states that Harvey never believed in the existence of lacteals. We owe much to the zealous anatomists of the Windmill Street school, who investigated the lymphatics ; now their origin, course, and termination in man's body are as plainly depicted in text-books as roads are delineated on motor maps.

Lymphatics are the subtile channels by which infective material reaches the circulation for distribution—and mischief.

The Glandular Pantheon.

One of the oldest occupations is that of shepherd, and the stockyard might not inaptly be called the cradle of physiology. For centuries shepherds have known that complete removal of the genital glands renders animals useless for reproduction, but makes them docile and fat.

Few suspected that other glandular organs were associated with growth and reproduction until it was discovered that complete removal of the thyroid gland induced myxœdema. Gradually the long-suspected relationship of the thyroid to cretinism was established. As with all knowledge that depends on observation, progress was slow :

> Precept must be upon precept, precept on precept, line upon line, line upon line, here a little, and there a little.

This surely applies to the slow accumulation of our knowledge concerning the potency of thyroid secretion and its influence on the metamorphosis of animals.

Two structures in the body of vertebrate animals have always had for me peculiar fascination—the notochord and the pituitary body ; each is as constant as a backbone. The discovery of the influence of the pituitary secretion on the growth of bones opened the eyes of physiologists, and they slowly realised that the growth and development of animal bodies are governed by a glandular pantheon and of the divinities in this pantheon, the pituitary body presides over the growth of the skeleton.

Avian Clubs.

Some remarkable effects of glandular activity on the character and dress of birds may be studied in sparrows. In winter these birds, cocks and hens, live in flocks, and their twittering in the trees at sunset is a familiar feature in the dull season. These societies may be called avian clubs, and they are sociable meetings, for in winter the testicles of the cocks are about the

size of the pips of pippins. In March, as the days lengthen and there is more sunshine, the testicles enlarge, and in May they are as big as sparrows' eggs. Apart from the special reproductive

FIG. 16.—Jackson's whydah bird (*Drepanoplectes jacksoni*) in wooing-dress. In this plumage it may be described as a sparrow in widow's weeds.

functions associated with the testicular increase, there are two features of importance ; the colour of the feathers is more vivid,

Fig. 17.—The feathery dancer in its grass amphitheatre or playing ground.

and the bird becomes pugnacious and combative. The sparrow is such a common bird that most of us take as little notice of it

as of the Litany, but the nut-brown plumage of the cock sparrow in April is exquisite, when with trailing half-spread wings he deploys before the coy hen and is so absorbed in the pursuit as to forget the presence of man.

Jackson's whydah bird presents a good example of resplendent nuptial plumage. This bird is closely allied to the sparrow, and in the quiet season it is difficult to distinguish by plumage the cock from the hen. On the approach of the pairing season the cock undergoes an extraordinary change. All the feathers except the primaries and secondaries become black (Fig. 16). The tail feathers lengthen and assume a sickle shape. In flight, the tail spreads out like a parachute, and the bird seems to float rather than fly. During courtship the cock indulges in extraordinary antics, in which wings and tail play a conspicuous part (Fig. 17). At the end of the breeding season the cock moults, and cocks and hens live in communities, consisting of thousands, among the reeds.

It is remarkable that this finch in a few days produces a large amount of feathers, large in comparison with its bulk, and as black as ink. The source of the pigment is unknown. I often think that if its source were known, much of our ignorance in regard to melanoma would be dissipated.

It is a simple question to ask, Why does the cock have such fine plumage for the ceremonies of courtship, whilst the hen is covered with sombre feathers ? It is more puzzling to explain why a hen, when she grows old and ceases to lay eggs, occasionally becomes cock-feathered.

In 1917 the College of Surgeons acquired the drawing of a duck (Fig. 18) feathered like a drake, even to the curly feathers on the tail. Under the drawing, in John Hunter's handwriting, is the statement that the bird made a noise sometimes like a duck and sometimes like a drake. The sexual difference in the voice of the duck and the drake is well known, and is associated with a modification of the syrinx. In the drake there is a thin

transparent osseous bulb (Fig. 19) or labyrinth connected with the trachea and syrinx. The quack of the duck is loud and sonorous ; of the drake, inward, harsh, and feeble. On a dark night, when these birds assemble by hundreds in marshes and shallow estuaries, they quack apparently for the sake of keeping

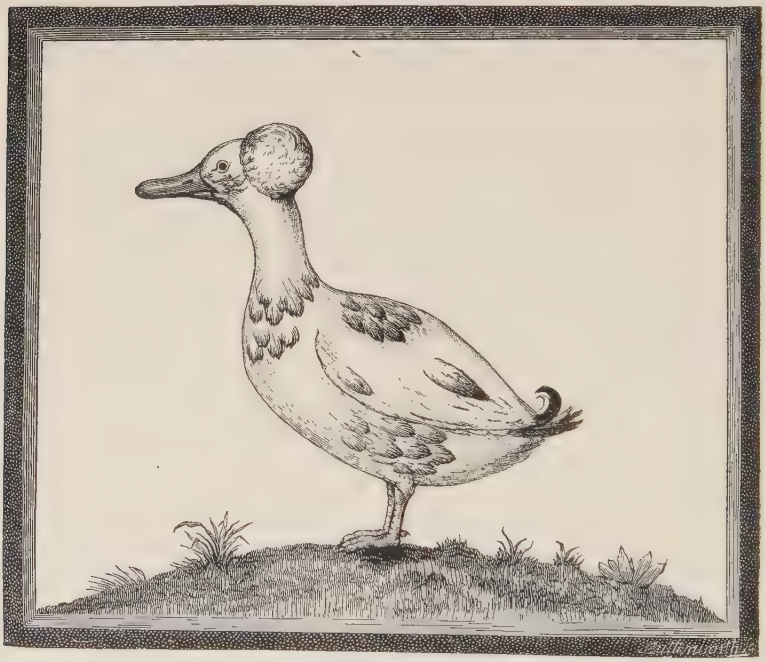

Fig. 18.—Duck in drake plumage (Hunterian).

company (Gilbert White). It is easy to distinguish the voice of the duck from that of the drake. It would be useful to ascertain if drake-feathered ducks also acquire a labyrinth to their syrinx.

Testicles and Feathers.—The relationship of testicles and feathers has practical importance for the ostrich farmer. Stanley Elley, a veterinary surgeon, practised the caponising of

ostriches in South Africa to check the breeding of inferior birds. The operation also enhances the value of feathers, tames vicious birds, and produces good parents. During the Great War caponisation practically ceased because of the slump in ostrich feathers, and the number of birds has decreased.

In a bachelor ostrich the testicles weigh about an ounce, but

FIG. 19.—The syrinx of a drake (*Anas boscas*).

in an old cock a pair weigh about 2 lb. The operation is not difficult, the risks are small, and the bird seems immune to peritonitis. In the hen the ovary is removed with good results. In cocks the effects of castration on the feathers is due to the subsequent docility of this combative bird. Fighting spoils feathers. In the hen the value of the feathers is enhanced

because the bird becomes cock-feathered and the feathers tend to become black.

A critic may ask, What have testicles to do with feather production when a hen without any trace of ovarian or testicular tissue becomes cock-feathered ? The evidence suggests that the endocrine glands are closely correlated in sex manifestations. Morgagni is credited with the observation that there is relationship between the development of the cerebral cortex and the cortex of the adrenal, but it is a modern discovery that the adrenals are associated with the activity of the sexual organs. Mott regards the adrenal cortex as a storage of lipoid : in the fœtus it builds up the myelin of the developing nervous system, but in adults, as occasion arises, this lipoid can pass into the blood and keep constant the supply for the reproductive organs, where it serves as raw material for formative nuclear activity, an action essential for the production of spermatozoa.

The hormone secreted by the genital glands must be very potent, for the engrossment of the sexual act is such that amplectant frogs are often transfixed by inquisitive boys with sharp sticks, and Phinehas, Aaron's zealous grandson, treated Zimri, a man of Israel, and the Midianitish woman, Cozbi, in the same way with a javelin (Num. xxv. 7). Shackleton obtained photographic evidence that love is as ardent among beasts and birds during the cold summer of the Antarctic as in the heat of the Torrid Zone.

Skunks.

The enterprising spirit of South African veterinary surgeons is matched by their colleagues in Canada and the United States where they make skunks as respectable as castrated cats, and much more profitable. Young skunks are obtained in May, as soon as their eyes are open, for then they are easily weaned and will eat bread and milk. The anal glands—scent-sacs they are

euphemistically called in America—can be easily, safely, and almost painlessly excised in the young skunk. The operation called disarming the skunk, requires for its performance a scalpel, forceps, clamping forceps, hook, probe, and a pair of goggles. The clamping forceps prevents the escape of the stinking fluid, and the use of goggles protects the operator's eyes in case of such an accident.

A disarmed skunk makes a good pet, and may be carried about like a kitten ; it eats dead fowls, mice, fruit, vegetables, grubs and beetles. Skunk fur is admired by women, and the fur can be improved by cross-breeding.

Lamps and Specialism.

Before the invention of the incandescent lamp, the chief specialities rested on instruments that reflected sunlight, lamplight, or gaslight. By such simple means advances were effected in laryngology, ophthalmology, and gynæcology. The incandescent lamp enabled ingenious instruments to be constructed for illuminating internal cavities. To this class belong the cystoscope, bronchoscope, and sigmoidoscope. Each instrument requires skill in employment and experience in interpreting things seen. This accounts for much dismemberment in clinical surgery.

Radiology has transformed the methods of diagnosis in respect of intrathoracic disease. Good skiagrams of the chest will reveal calcified lymph-nodes, tumours of the mediastinum, and aneurysms of the big vessels. With the help of an opaque meal an intrathoracic stomach has been identified, and an œsophageal diverticulum can be localised and its size and suitability for removal duly estimated.

In the case of a foreign body in the chest, the utility of the X-rays has long been demonstrated, and the detection of a sovereign or a bicycle—a toy bicycle—in the gullet excites

curiosity, but it is a dramatic spectacle to watch a shrapnel ball in a cardiac ventricle, rapidly moving in its orbit, and recalling, in its activity, Phobos, the little satellite of Mars.

The chest is now an established field for surgical enterprise. There are indications that X-ray lamps and screens will be as available in wards and consulting-rooms as incandescent lamps are to-day.

The art of surgery is now so wide that no man can expect to be expert in all branches. Specialisation is a necessity of modern surgery ; the Association will help to concentrate the results and keep surgeons abreast of the progress made in the great hospitals of the kingdom. Apart from the regular discussions, personal conversations will be even more useful, and promote good fellowship among surgeons.

Before all things let us remember that fellow craftsmen should not be competitors, but comrades of the same honoured craft or guild.

VI

THE WAR PATHOLOGICAL COLLECTION OF THE ROYAL COLLEGE OF SURGEONS

In 1917, I was appointed War Office representative (with the rank of Lieutenant-Colonel) for the collection of pathological specimens illustrating gunshot injuries. I went to Paris and studied the war specimens exhibited in the museum at the Hôpital du Val de Grâce, visited various hospitals in the military zone, and explained to the pathologists the kind of specimens required. I remained the representative of the War Office until the Collection was intrusted to the Royal College of Surgeons, 1922. The subjoined article relating to the Collection was introductory to the seventh volume of the *British Journal of Surgery*, 1919.

Scattered in many museums of pathology there are specimens illustrating injuries incurred in warfare. Some of them date from the Napoleonic wars, especially the Peninsular Campaign and Waterloo. Few of the specimens do much to illustrate pathology, and most of them may be regarded as mementos, or as curious examples of the vagaries of missiles. Some are interesting inasmuch as they recall the names of famous military surgeons. Specimens from the Crimean War and the Franco-German War are mainly macerated bones showing fractures produced by bullets. Even from the South African campaign such soft specimens as are available were obtained by personal effort ; no systematic effort was made by the Medical Department of the Army to secure preparations for illustrating injuries of the human body caused by the destructive weapons used in modern warfare and to prepare and arrange them for reference and study.

In 1914 a committee was appointed to compile a medical

history of the Great War, and this committee soon appreciated the importance of obtaining specimens demonstrating the effects of modern projectiles on the bodies of men, and of having such specimens prepared, suitably preserved, and catalogued.

In preparing the specimens great care has been taken to preserve the injured parts in their anatomical surroundings; instead of dissecting out a damaged artery or vein, and slitting it up to show the rent made by a missile in its wall, the region is dissected and preserved, whenever possible. Some of these "regions," dissected with great skill and care by Cecil Beadles, may be described as works of art. Moreover, the old method of preserving the specimens in alcohol has been abandoned, solutions of formalin, and glycerin, being freely used. These liquids have been on trial at the Royal College of Surgeons for a sufficient length of time to justify the opinion that they are superior to the old spirit-and-water method. It is proper to mention that much of the success of the wet specimens is due to the careful pickling they received from the officers at the various military hospitals in France. Instructions in regard to the preliminary treatment of the parts were circulated, and they have been so thoroughly followed that the majority of the specimens reached the college in good condition.

It is an interesting feature of the Collection that many of the communications that have appeared already in medical journals concerning gunshot injuries incurred in the Great War, relate to specimens belonging to it; thus the Collection may not inaptly be regarded as a Pathological Record Office.

To the military surgeon these excellent preparations of injured organs, carefully catalogued and described, with the chief facts of their clinical histories, will be used by authors as type specimens in the same way that zoologists, botanists, and geologists use the contents of the Natural History Museum when they wish to compare new species, or suspected new species, of plants, fishes, reptiles, birds, or beasts that live on the earth,

or the fossilised remains of those that formerly moved about the earth or inhabited its waters.

In collecting material useful for illustrating gunshot wounds, specimens were obtained from the battlefield in which projectiles induced instantaneous death. This can only happen in two situations—the head and the heart. In the early stages of the war there was some fear that, without special effort, only specimens obtained from patients admitted to the hospitals would be available for museum purposes. Thanks to the zeal of the medical officers in France, especially Dr. T. R. Elliott, C.B.E., D.S.O., some instructive specimens have been preserved. So remarkable are the effects produced by a bullet of high velocity traversing the head of a living person, that the skull is often burst as by an explosion. The most characteristic effects are produced when a bullet enters the forehead and escapes by the occiput, or *vice versâ*. The bullet enters by a neat round hole, but the bone in the neighbourhood of the hole by which it escapes is broken into fragments ; indeed, the cranial wall is broken and cracked like a pane of glass shattered by a stone. A critical examination of the macerated skull shows that the lines of sutures are often " started," and occasionally opened. This indicates that the intracranial pressure imparted by a bullet traversing the brain with a high velocity must be enormous. This is not a peculiarity of the elongated and pointed bullets used in the British, French, and German armies. Similar effects were recognised in the case of the Snider rifle ball. Kipling expresses this in his well-known verse on " The Grave of the Hundred Head " :—

A Snider squibbed in the jungle—
Somebody laughed and fled,
And the men of the First Shikaris
Picked up their Subaltern dead,
With a big blue mark in his forehead
And the back blown out of his head.

The physical disturbance engendered by a bullet traversing the

brain, or any hollow organ filled with fluid or viscous material, must be very great. In the case of the brain it leads to instant paralysis ; circulation and respiration are completely stopped.

Instantaneous death from a high-velocity bullet traversing the head is a marked contrast to the long-drawn-out helplessness that ensues when a soldier has his back broken by a bullet. Examples of gunshot wounds of the spine are numerous in the Collection. They are most depressing specimens ; they recall the long-suffering wounded soldier whose existence can only be described as a living death. An analogous condition can be studied in the insect world. The inimitable observer, Fabre, has described the fiendish method employed by a digger-wasp, *Sphex*, for provisioning the brood chambers with crickets. This wasp paralyses crickets by stinging them in the nerve ganglia. *Sphex* then deposits an egg on the ventral surface of its paralysed victim. The larva, hatching out in a few days, eats and thrives on the soft tissues of the living, helpless cricket.

A soldier with his spinal cord damaged lies like a paralysed cricket, living, but unable to move, and conscious of his helplessness. The hole by which the bullet entered his spinal canal admits pathogenic and saprophytic micro-organisms to prey, and flourish, on his tissues like the larvæ of the fossorial wasps on helpless crickets. There is no class of gunshot wound that entails more mental misery than gunshot wounds of the spine, and few in which the resources of surgery and bacteriology are so helpless to cure or relieve, and none that excites so much compassion.

In the case of the heart, when traversed by a high-velocity bullet, death is usually instantaneous, the dynamic disturbance causing it to stand still. Failing an instant paralysis, the wounded heart bleeds so freely and rapidly that death occurs in a few minutes. In big game-shooting it occasionally happens that a large beast is brought to the ground by a broken back. When such an animal is deliberately finished by a bullet sent

through its chest, either fore and aft, or from side to side, it dies instantly. On opening the chest, the heart will be found firmly contracted, and often there is no effusion of blood, either in the cavity of the pericardium or of the pleura. The effects of a sword plunged into the heart may be watched in the bull ring. When the matador thrusts the weapon directly into the heart the bull sinks instantly on the floor of the ring ; but when the sword wounds the big vessels at the base of the heart the bull may move about for many seconds whilst the blood escapes.

In previous wars little attention was given to gunshot wound of the heart ; they have been regarded as nearly always fatal. Indian sportsmen have often drawn attention to the fact that a tiger, shot in the heart, has had the strength to run for many yards before falling dead. Some of the hearts in the Collection show the destructive effects which modern missiles exert upon the thick walls of the ventricles. One heart, extensively lacerated near the apex by an armour-piercing bullet, merits attention. It belonged to an officer who was hit when flying over the German lines. He brought the aeroplane to earth in his own lines, but was dead when removed from the machine.

Farina, in 1896, proved that wounds of the heart are amenable to surgery ; and his example influenced the treatment of such wounds during the Great War ; there are specimens illustrating surgical enterprise in this direction. But the surprise of the Collection is a series of specimens indicating the methods and routes by which missiles reach the cavities of the heart : they prove that missiles occasionally enter the cardiac cavities by directly penetrating the walls of the heart, or arrive as flotsam and jetsam in the blood-stream. The evidence supplied by the specimens shows that fragments of metal, and entire bullets—shrapnel and rifle—penetrate large veins, such as the pulmonary, iliac, hepatic, and caval, and are transported as emboli to the heart. Some of the missiles, after reaching the auricular or ventricular cavities, have been retained. A few, embedded in

clot, have been discovered post mortem. In several instances bullets have been detected radioscopically in the heart cavities during life, and their swirlings and gyrations in the blood-current, during systole and diastole, have been watched with the same interest that astronomical observers bestow on minor planets.

In some instances, bullets round and conoidal, or irregular fragments of metal, after reaching the cavity of a ventricle, are discharged and become dangerous emboli. There are specimens in the Collection, exquisitely prepared and displayed, showing metallic emboli impacted in the pulmonary artery producing infarction of the lung. Others, lodged in the iliac arteries, caused ischæmia of the lower limb. The series of hearts showing the effects of gunshot wounds is probably unique.

Even more remarkable are the specimens proving that bullets may penetrate large blood-vessels, like the aorta, and become centrifugal emboli, being propelled by the arterial current, or slip along the vessels by their own weight, until they become impacted in the common or the external iliac artery. These extraordinary events and sequences are not only represented by specimens, but complete clinical histories are available ; the names of the officers who made the observations and carried out the treatment are duly recorded.

In a few cases the missiles within the chambers of the heart came as a post-mortem surprise, but in many instances the nature of the embolus has been recognised during life ; in one instance a missile was observed in the heart radioscopically, and a few hours later it was detected by the same method in the common iliac artery (O'Neill). The parts belonging to this remarkable case are preserved in the Museum.

Few specimens illustrating gunshot wounds of the viscera have been obtained in previous wars. In spite of the enormous development of abdominal surgery during the last thirty years, attempts to apply surgical measures to the treatment of gunshot

wounds of the gastro-intestinal tract during the South African War were discouraged. In the early period of the Great War few gunshot wounds of the intestine were submitted to operation. Many soldiers, shot in the lower abdomen, die in a few hours from hæmorrhage in consequence of wounds of the large vessels in the mesentery. Many who survive the bleeding die a few days later from sepsis due to leakage from perforations in the gut. Some surgeons believed that the modern elongated bullet produced a small hole in the intestine, and this accounted for the occasional recovery of men shot in the belly, under expectant treatment. An examination of the wounded segments of small intestine in the Collection, showing mucous membrane everted and protruding from the bullet holes like the corolla of a full-blown flower, will quickly dispel such an illusion. There are some instructive examples of the surgeon's skill in dealing with wounded intestine. Many reports have been published in which officers operating often in circumstances requiring courage as well as dexterity and resourcefulness, have succeeded in saving the lives of wounded soldiers in apparently desperate circumstances.

Coils of ileum showing multiple bullet wounds demonstrate that one of the problems facing the surgeon is choice of method. Is it better, in such injuries, to resect several feet of intestine, or patiently close the shot holes with sutures ? Some surgeons believe that the resection of a portion of small intestine for gunshot injury is often followed by recovery, but that double resections are attended with a high mortality. If those who have been occupied with this class of surgery in France would publish their observations it would help to guide surgical opinion on this important matter. Such a question could not be properly answered by a study of wounded intestines in a museum.

It is reasonable to believe that a soldier is more likely to recover after the removal of 6 inches than after the loss of 6 feet of gut. More than one case is known in which recovery has

followed the resection of 2 yards of ileum. A notable specimen is a coil of small intestine, 6 feet long, with twenty perforations. In some parts the gut is so damaged that two-thirds of its circumference is torn through. This piece of ileum was excised by Owen Richards from a Scotch Canadian. The soldier after receiving this injury in a German trench, walked back to his own lines "because he wished to die among friends." He recovered.

The first specimen received at the Royal College of Surgeons for the Collection was a piece of intestine $4\frac{1}{2}$ feet long, perforated in two places. The appendix was also perforated near its base. This piece of gut and the appendix were excised by Owen Richards.

The point of entry of a missile into a belly is no guide to the damage inflicted on the viscera. For example: a bullet entered the belly of an officer 5 centimetres above the highest point of the left iliac crest; passed through the transverse mesocolon, stomach (two places entry and exit), and the diaphragm; it then entered the right ventricle of the heart and perforated a flap of the tricuspid valve. It was expelled as an embolus into the right pulmonary vein. The officer died eleven and a half hours after being hit (A. Fullerton). We may compare with this a vermiform appendix (637). A soldier was hit in the flank. The appendix was perforated by the bullet, no other organ in the abdomen being injured. No details of the operation are available, but there is this laconic official statement, "Patient evacuated to base."

An instructive specimen is a Meckel's diverticulum with two perforations. A soldier was hit by a piece of shell in the right buttock; the missile passed into the belly by the side of the rectum, and made sixteen holes in the ileum, two holes in the diverticulum, and several holes in the mesentery. It was necessary to resect $3\frac{1}{2}$ feet of ileum. The soldier recovered (Gordon Taylor).

When a soldier, wounded in the buttock, complains of intense pain in the belly, the surgeon, finding a wound in the buttock and none in the belly wall, is apt to overlook the serious nature of the injury.

Even those who regard a museum mainly as a repository of curiosities will find these pathological specimens interesting. Bullets attain more curious positions by accident than they could obtain by design. This has been a subject of perennial interest since the invention of firearms. The classical instances are bullets embedded in the solid portions of the tusks of elephants. The Odontological Section of the Hunterian Museum contains some admirable specimens of this kind. The mode by which metallic bodies, and even spear heads, become encysted by secondary dentine, is almost as fascinating as the ways by which bullets reach the cavities of the heart of man. Each in turn demonstrates the importance of scientific studies in explaining such apparently mysterious occurrences.

The manner of the encystment of missiles in tissues shows that when metallic bodies are germ-free—sterile—apart from the injury inflicted when traversing the tissues they lead to little inconvenience. But a fragment of metal soiled with mud, or a piece of germ-laden skin entering the head, trunk, or limb of a living person, may be as lethal as a cobra bite. A small piece of metal may pierce a man's forehead and sink an inch or more into his brain ; this does not necessarily lead to death. But a similar fragment of metal entering the back of his head and carrying some dirty hairs from the scalp to the inner side of the dura mater will amost certainly lead to fatal meningitis. Surgeons were long in learning this simple lesson.

The same important truth may be learned in any part of the body. A soldier may have a portion of a digit carried off by a bullet and die from septic infection. Another may have his lower abdomen traversed by a bullet, and recover after a temporary indisposition. The size of a missile is no guide to its

killing powers. The nosepiece of a shell as big as a duck's egg has lodged in a man's buttock and done little harm, but a ragged piece of metal a centimetre in diameter has broached the aorta, or the vena cava, with rapidly fatal consequence from bleeding. A 7-mm. revolver bullet has passed through the superior mediastinum of a man and lodged under the vertebral border of the left scapula, and caused merely a blood-stained pleural effusion from which the man recovered.

Strange things which have been converted into missiles by the impact of projectiles are sometimes found in soldiers. The impact of a high-velocity bullet against a button on a soldier's tunic sent it forward with such force against a guardsman's face that it became embedded in his upper jaw. The radioscopic appearances were puzzling; and the surgeon was astonished when he extracted the missile and found it to be a button with its shank intact. The strangest missile of this kind in the Collection is the terminal half of a man's finger, converted into a missile by the impact of a bullet and deeply implanted in a soldier's thigh.

The damage caused by inert bodies converted into missiles by the impact of high-velocity projectiles, apart from explosive effects, is seen at its maximum in relation to eyes. The number of soldiers blinded in one or both eyes is greater than in any previous war. This is due, not only to the large size of the fighting forces, but also to the great power of the explosives employed. Sir William Tindall Lister, K.C.M.G., has prepared an exquisite series of eyes destroyed by missiles which is of great value as illustrating the effects of gunshot wounds. These specimens show that a fragment of metal, a little bigger than a grain of sand, if it pierces the coats of the eye, almost invariably entails destructive septic changes.

Lister's preparations also show that when a missile, moving with a high velocity, enters the eye, it produces the same explosive effects which have been referred to in connection with

bullets traversing the head. The Collection contains some specimens showing the tunics of the globe burst by this disruptive force. Lister's Hunterian Lecture contains an admirable description and explanation of these grave injuries.

There is another valuable use for this Collection. Every museum of natural history and allied subjects, to be valuable as well as useful, must grow and expand with the advance of knowledge. As it stands to-day, the Collection contains many carefully prepared specimens illustrating a series of grave and extraordinary injuries. Many of them represent damaged organs and limbs removed in the course of operations from soldiers who survived. Thousands of soldiers remain more or less disabled in consequence of their primary injuries. We want to know the subsequent history of such men. Grave injuries of the brain have in many instances been followed by recovery; the condition of the men five or ten years later will be of extreme value: the secondary changes following severe cerebral lesions should be studied, and the complete clinical course of the patient duly recorded.

Much valuable knowledge may be gathered concerning the usefulness of many procedures practised for injuries of main arteries. The ultimate effects of ligature practised on the iliac, subclavian, and especially the carotid, arteries, should be followed up and the notes added to the case histories.

It will be of value to ascertain the fate of bones in which fractures have been "plated," and especially those in which gaps have been filled with bone grafts; also the late condition of men's faces who have had extensive plastic operations performed in the neighbourhood of the mouth and nose.

There are many things we require to know in regard to operations performed for the repair of injured nerves. Specimens are needed, not only to demonstrate the changes in the nerve trunks, but also the secondary changes in the bones belonging

to the paralysed sections of the limbs. Actual specimens are more useful than pages of descriptions.

Zealous officers, interested in surgical pathology, have secured much valuable material for showing the effects of gunshot injuries ; if equally enthusiastic in securing specimens illustrating the remote effects of such injuries, and adding them to the Collection, they would enhance its value for future generations of surgeons. It may seem to many that it is not necessary to trouble about war wounds in the future. Whatever politicians desire, or statesmen arrange, no thoughtful person can doubt that as long as the earth is inhabited by human beings, disease and war will not cease.

VII

SPOLIA NEMORALIA

(SHRUNK HEADS, EAR PLUGS, AND LABRETS)

(*An Address to the Royal Society of Medicine, November*, 1922.)

INDIANS living in the dense forests bordering the section of the Amazon called the Marañon have acquired notoriety in preparing what are known in England as "shrunk human heads." While on a visit to the Amazon I got some of these curious heads and have been able to examine them critically, and also obtained some stories concerning the Indians.

Recently G. M. Dyott made an adventurous journey across Peru to Iquitos. After being treacherously abandoned by his guide on the return journey, he was rescued by some Aguarunas. Dyott, virtually a prisoner for many weeks, won the confidence of the Indians, and they helped him to reach Lima. While with the Indians he acquired some knowledge of their language, the secrets of the community, and a first-hand knowledge of their customs. These he described in his book entitled "The Silent Highways of the Jungle" (1922).

The Aguarunas are well formed, with coppery skins and long raven-black hair, which is cut into a fringe across the forehead. The men average in height $5\frac{1}{2}$ feet, the women rarely exceed 5 feet (Fig. 20).

The men are clever hunters, use the blow-gun skilfully, and can hit a monkey, as it jumps from tree to tree, with the poisoned dart. They live on bananas, mandioca, and fruit. They also

eat fishes, tortoises, sloths, monkeys, small wild pigs, and birds, especially toucans and parrots. The women are drudges ; they collect, prepare, and cook the food. The men hunt and fight;

Fig 20.—Family of Aguaruna Indians, showing the style of hair-dressing. The man has a blow-gun. (After G. M. Dyott.)

n their hours of ease they amuse themselves spinning thread from wild cotton, and weave the material for the scanty clothes they wear.

In civilised countries human beings wear clothes for decency, protection against weather, and for warmth. With the Aguarunas decency does not count. Their scanty clothes protect them against insects and thorns. When it rains they take off their clothes, carefully fold them, and use large palm leaves to keep themselves dry.

The Indian boy (Fig. 21) shows well the luxuriant growth of hair and its arrangement. He is equipped for accompanying his father in the forest. The quiver, made of bamboo, contains light wooden poisoned darts, slender as knitting-needles ; the gourd attached to it contains a supply of wild cotton, which is used for adjusting the darts to the lumen of the blow-gun. The cotton is obtained from the seed vessels of the silk cotton tree (*Eriodendron*).

The pointed tip of a dart is smeared with woorali, the South American arrow poison. A mere scratch of the skin made with the tip of such a dart is quickly fatal, but a moderate quantity of woorali

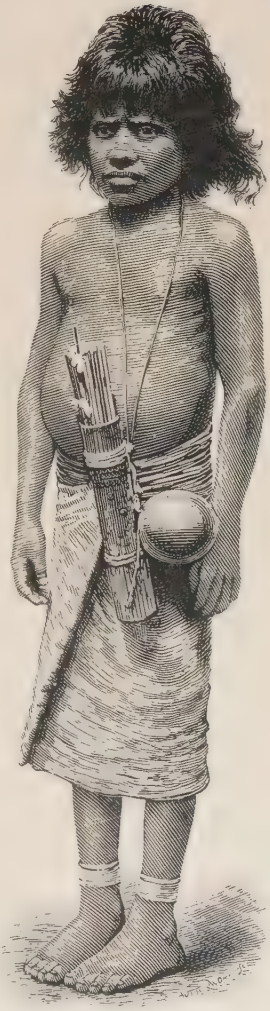

FIG. 21.— Aguaruna boy equipped for the forest. (G. M. Dyott.)

may be swallowed without harm. The flesh of a bird or an animal killed by a poisoned dart is eaten without danger.

FIG. 22.—Shrunk head of an Aguaruna. The hair has been removed from one side to afford a view of the scalp and to expose the line of the incision, which permits the extraction of the skull (half natural size). The material used to sew the lips together is twisted cotton thread. The scalp is slung by a plaited loop.

The Amazonian Indians are familiar with the process of mummifying dead bodies. As a rule a corpse is flung into the

river, but when killed in combat the body is mummified, wrapped in bark, and placed on a stand in the centre of the hut as an object of veneration. Some notion of their methods of mummification may be gathered from the way these Indians treat the heads of victims slain in combat. The conqueror cuts off the head, splits the scalp by a vertical incision in the occipital region (Fig. 22), and neatly removes the skull with the brain, eyes, muscles, jaw, and tongue, leaving the skin of the face and the scalp intact. The incision is closed with a continuous stitch and the cutaneous bag is packed with hot pebbles, or hot sand, and carefully dried in the sun. When this crude taxidermic process is complete the skin shrinks to the size of an orange, preserving the features. The lips are stitched together with threads, which are left long, and dyed red in such a way as to present alternate bands, coloured and uncoloured (Fig. 23). In some preserved heads that I have examined, the upper and lower lips are fixed together by wooden skewers and secured by cotton cords wound round them in the style known to surgeons as figure-of-eight. The lips are sewn together to prevent the victim retorting when his conqueror freely curses him, and to condemn him to eternal silence ! A cord is attached to the vertex of the scalp to enable the trophy to be slung on the girdle of the warrior. Some of the cords are decorated with scarlet feathers. The skin of the face is smoked, polished, and sometimes smeared with red dye.

There are two shrunk heads in the Natural History Museum, South Kensington, probably the first examples seen in London. They were shown to the Anthropological Society, Paris, in 1862, by Dr. Moreno-Maiz, formerly surgeon-in-chief of the Peruvian army. He presented them to the museum. The heads were given to Moreno-Maiz by M. Galvey, the Peruvian Minister in Paris ; they were found in an Inca tomb in the territory occupied by Jivaros Indians (Ecuador). Moreno-Maiz appreciated the heads as excellent examples of taxidermic art, detected the

Fig. 23.—Shrunk head of an Aguaruna.

manner in which the skull had been removed, and the skill with which the shrinking had been carried out with conservation of the features. Dr. Bellavisencio examined pieces of the mummified skin histologically; sweat glands and their ducts, hair bulbs and sebaceous glands, and the layers of epidermis were easily recognised.

The heads were those of Jivaros warriors, and were probably preserved from religious motives, for these Indians did not bury the heads of the dead with their bodies in cemeteries, but after conservation placed them around their houses and preserved them with respect, for these cherished remains protected the families from their enemies. For these Indians death was not a natural phenomenon—it was a consequence of witchcraft, the occult and culpable action of enemies, known and unknown. Bollaert published a good account of the Jivaros Indian in 1863.

The knowledge of this peculiar method of preserving heads has come down from the Incas of Peru. The body of a deceased Inca was skilfully mummified and removed to the great Temple of the Sun at Cuzco. The Peruvian sovereign on entering the sanctuary of the dead might behold the effigies of his royal ancestors ranged in opposite files—the men on the right and the queens on their left. The bodies, clothed in the princely attire which they were accustomed to wear, were placed on chairs of gold, their faces exhibiting the natural dusky hue, their forms and lineaments true to life (Prescott). Garcilasso saw them (1560) and described them as "perfect as life without so much as a hair or an eyebrow wanting."

Mummified Incas were treated with reverence, but to-day Indians living in the seclusion of the dense forests are described as devoid of emotions such as love, pity, admiration, wonder and joy. They are superstitious, and superstition is born of fear of spirits, good and evil. It is difficult to believe, as some assert, that Indians lack imagination when they practise the diabolical art of curing the skin of an adversary's head, shrink it to the

size of a lemon, preserving the features, even the eyelashes and eyebrows, and sew the lips together, so that when they curse the victim the leathery lips can make no reply. *Surely belief in spirits, good and evil, depends on the faculty of speech !*

In London there is now a fair number of these curious heads available for study. In addition to the two in the Natural History Museum the Royal College of Surgeons possesses six, and the British Museum three, as well as a collection of hunting and domestic implements used by the Peruvian Indians. The Wellcome Historical Medical Museum contains thirteen examples, and there are many kept as curios by travellers. When a demand for such heads arose many were forthcoming, but traffic in these gruesome objects is discouraged lest it lead to undesirable methods of obtaining them.

The specimen represented in Fig. 23 is in the Royal College of Surgeons. The hair is coarse like that of a horse's mane or tail, raven-black and 2 feet in length.

Ear Plugs and Labrets.

When Columbus discovered Honduras during his fourth voyage (1502) he named part of the seaboard "Costa de la Oreja," in reference to the ears of the natives enlarged with plugs. The Indians inhabiting the forests wear ear plugs and labrets. Some of the tribes were named by the Portuguese "Botocudos" on account of this habit, *botoque* being the Portuguese name for a plug. The ear plugs of the Botocudos are sometimes 4 inches in diameter. There are plugs of this size in the British Museum, and they resemble bungs. The plugs can be slipped in and out of the loops like buttons. Some ear lobes are so distended with huge plugs that they reach to the shoulders and resemble the wings of bats (Fig. 24).

Drs. Spix and Martius, in 1817, under the auspices of the King of Bavaria, made a journey for scientific purposes through

the Amazonian forests. Spix was responsible for zoology and Martius for botany. The first native American they saw was a boy of the cannibal race called Botocudos. He was in the house of M. von Langsdorff. The story of the boy is curious. A former Minister of State had applied to the district commander for an

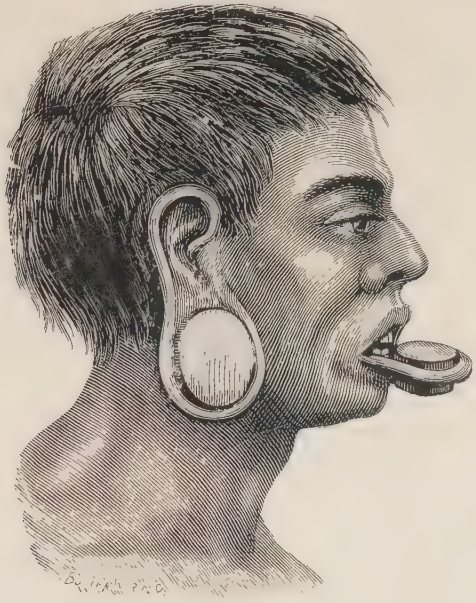

Fig. 24.—Head of a Botocudo with ear-plug and labret.

Indian skull which he required for Professor Blumenbach. The commandant had no opportunity for obtaining a dead specimen, so he sent two living Botocudos, who had been taken in a sudden attack by his soldiers. Von Langsdorff obtained one of them, to whom he soon became much attached, and " who served him not only as a living cabinet piece, but as a collector of objects of

natural history." This boy wore not only ear plugs, but also a large labret.

Ear plugs are instructive in regard to the view that the method of mummifying heads is of Incarial origin. The heir to the Inca throne received a military education with the sons of the nobles. At the age of sixteen they were submitted to a public examina-

FIG. 25.—Shrunk head of a Jivaro Indian with a spigot of wood in the lobe of the ear.

tion in order to show their prowess in the athletic exercises of warriors.

They were admitted into the order of chivalry by the Inca in the following manner: the novice knelt before him and he pierced the lobe of the ear with a golden bodkin, and this hole was gradually dilated until it became large enough to receive an

ear plug. " This monstrous deformity was regarded as a beauty by the natives " (Prescott).

The ears of shrunk heads sometimes contain a wooden spigot in the lobule (Fig. 25). The Royal College of Surgeons contains

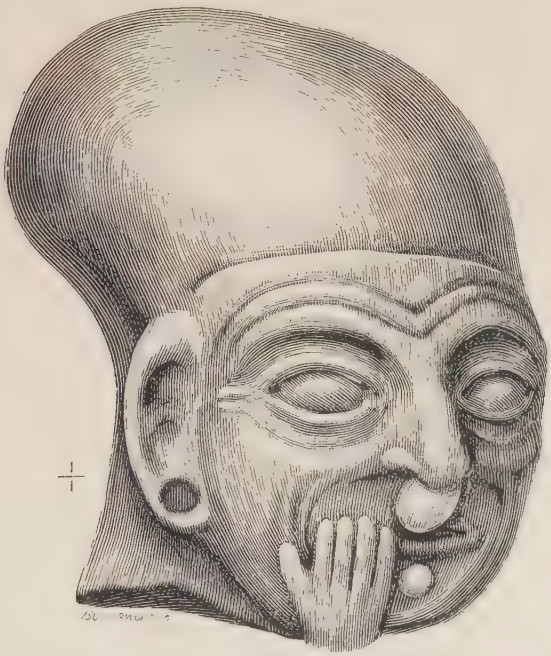

Fig. 26.—Head of baked clay with labrets and perforated ears. There was a ring of fine gold in the ear when it was dug out of a cemetery near Esmeraldas, Ecuador.

two examples, and I think this is peculiar to the Jivaros (Ecuador). There is a shrunk head in the British Museum, with preserved skins of brightly coloured birds hanging as ornaments from the lobe of each ear. Gorgeous plumes of feathers are worn by the men on festive occasions.

It is clear that there are two kinds of shrunk heads—one from enemies slain in combat and the other heads of chiefs. The former are freely cursed by their captors ; the latter, decorated with iridescent wing cases (elytra) of large beetles, bright-coloured feathers, and skins of gaudy birds, are venerated and worshipped as idols.

Fig. 27.—Head of Gotos Indian with ear plugs (A. Miles Moss).

Ear plugs and labrets had social and religious significance, and this is supported by an inspection of the curiously hideous figures of baked clay so common in Peru and Ecuador. I possess the head of one found at Esmeraldas in an ancient cemetery. The lips contain representations of labrets and the ears are perforated (Fig. 26). When this terra cotta head was dug up the perforations in the ears contained loops of fine gold.

The Rev. A. M. Moss (1909) succeeded in recovering some photographs, obtained by Mr. Kroehle, of Indians living along the tributaries of the Amazon. Some of these photographs show Gotos Indians with ear plugs (Fig. 27). Kroehle lived for some time among the Indians and received an arrow wound

FIG. 28.—Native of the Makonde plateau with labret and ear plug (Weŭle).

which "hastened his death." On the back of a photograph is written the significant word *Anthropophagus*. Spix and Martius reported that the Botocudos were cannibals.

Opportunities for seeing Indians in Brazil with ear plugs and labrets are rare. In British East Africa they are common, especially among the Masai and Kikuyu (Figs. 28 and 29). These deformed ears are objects of great pride to their possessors.

To break the loop is an insult, and when men quarrel they snatch at the ear loops. If the loop be completely detached the damage is irreparable, but if merely broken the torn ends are cut, the freshened edges are superimposed and held in position until bleeding ceases. The apposed ends of the loop are then bound

Fig. 29.—Kikuyu man with a plug of wood in the lobe of the ear.

together. Each tribe has a man who performs these operations. Without the plug the large ear loops resemble rubber rings, and the men loop them over the helix for protection.

The discs of wood for the upper lip are known among the African natives as the *pelélé*. Livingstone mentions them as

being worn by women on the Zambesi (1856); in the Rovuma valley he saw men as well as women wearing them. There are some good examples of labrets in the Ethnographical Department of the British Museum.

It is clear that Amazonian Indians, as well as the natives of East Africa, like surgeons in civilised countries, are familiar with the elastic properties of human skin. Shrunk heads, ear plugs and labrets appeal to me. My father taught me to stuff birds at the time my mother stuffed me with the Creed and the Ten Commandments. Later in life I saw savages ornamented with feathers, skins, teeth, and claws in tropical forests; similar decorations are worn by fashionable human beings who strut in Piccadilly or parade the paddock at Ascot.

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VIII

A CRITICAL STUDY IN CRANIAL MORPHOLOGY

(*The Journal of Anatomy and Physiology*, 1887-8, *xxii.* 28.)

Anatomists, as a rule, apply the term intra-cranial to any structure lying within the bony framework of the skull. Practically this may be the most useful definition of the term, but exception must be taken to it on morphological grounds.

We know that, in the course of development, the human skull passes through a membranous stage, then the base chondrifies. Later membrane bones are superadded to the cartilaginous skull, finally the cartilage is replaced, and the skull, for the most part, represented by bone.

If we wish to compare the disposition and relation of arteries and nerves in the various types of skulls, the comparison is best effected when the skull is in its embryonic condition. Suppose we choose the human skull when it is fully chondrified, and examine the course of the various nerves, we shall be much surprised and interested at the simplicity of their courses.

In order to study the relations of nerves to the chondral skull, a fœtus should be chosen between the third and fourth months. After the skin has been removed and the head soaked for some hours in running water, the various bones preformed in membrane, such as the squamosals, parietals, frontals, nasals, etc., can easily be removed without damage to the underlying cartilage.

A long series of dissections, conducted in this manner, shows clearly enough that the cranial nerves and their branches follow

fairly direct courses ; and the intricate paths followed by many nerves in the adult skull are entirely due to the modifications induced by the addition of osseous material, and the remarkable changes which occur in the branchial apparatus, the result of the transformation of an aquatic into a terrestrial animal.

The nerves most affected in this metamorphosis are the fifth, seventh, and tenth. With these three nerves our attention will be chiefly occupied.

These nerves agree in one or two important particulars, but differ in others, whilst a comparison of the points of agreement and difference leads to a conclusion of some importance.

The three nerves are in agreement, inasmuch as they develop on their main trunk, soon after quitting the brain, a ganglion ; but there is considerable variety regarding the position of this ganglion. In the adult skull the ganglion of the vagus lies outside the bony skull, that of the facial is enclosed in the petrous bone, whilst the Gasserian ganglion is lodged in a compartment of dura mater, known as the cave of Meckel.

The course of the vagus, from its ganglion onward, is purely extra-cranial, but the facial traverses the curious Fallopian canal, to emerge at the stylo-mastoid foramen, whilst the subsequent course of the fifth is even more labyrinthine.

On examining the trunk of the facial nerve in a fœtus at birth, we shall be astonished to find, on removing the dura mater from the periotic bone, that the geniculate ganglion, with its petrosal branches, is exposed to view in a recess, which later becomes roofed by a thin plate of bone. The obvious deduction from this is that the remainder of the course of the facial nerve is extra-cranial, and this is further supported by the fact that in the chondral skull the facial lies on the inner wall of the tympanum, merely covered by membrane.

Gegenbaur, in 1876, drew attention to the fact that the course of the facial nerve from the hiatus outwards is extra-cranial (*Morph. Jahrb.*, 1876, Bd. 11).

When we come to deal with the fifth nerve, we find the ganglion entirely closed in by dura mater ; but the nerve enters this cave by a very distinct opening at the apex of the periotic bone.

A careful examination of these conditions led me to propound the view, that morphologically the true cranium is limited by the dura mater, and that any structure quitting the brain becomes extra-cranial at the spot where it perforates the dura mater. If this be so, then the Gasserian ganglion and its branches, including the nasal nerve, the structures in the cavernous sinus, the geniculate ganglion of the seventh with its petrosal nerves, the tympanic branch of the ninth and tenth nerves, the internal carotid artery, from the anterior clinoid process downwards, and the meningeal vessels, must all be for the morphologist extra-cranial.

If it be admitted that structures situated between the dura mater and the osseous walls of the skulls are morphologically extra-cranial, then there can be no difficulty in dealing with the distribution of the nerves between the place where they quit the basal foramina and the spot where they emerge from the secondary osseous passages, such, for example, as the stylo-mastoid and infra-orbital foramina, the inferior dental canal, etc.

If we accept this view, then the subsequent portion of my labour becomes easy, for the intricate pathways of the distal portions of these nerves must be regarded as a species of entanglement due to increased growth of the brain, and the consequent encroachment of the cranial cavity on the face ; the modification of the appendicular elements of the skull, and the addition of membrane bones.

In order to render the matter clearly, let me take each nerve foramen in the skull base in order. The result will be to show that when a nerve passes through an osseous opening it passes between two or more bones, or between two or more centres of ossification.

The French anatomist Serres drew attention to this in 1819,

but at that time the exceptions were very numerous. Now only one foramen is obdurate, the foramen rotundum.

The Optic foramen marks the confluence of the orbito- and pre-sphenoid centres. The Sphenoidal fissure is bounded by the orbito- ali- and pre-sphenoid completed externally by the frontal. At birth the Foramen ovale is a notch in the posterior border of the ali-sphenoid, converted into a foramen by the periotic capsule. The Auditory foramen is an opening between the pro-otic and opisthotic centres. The Jugular foramen is bounded by the basi- and ex-occipital elements, and completed externally by the periotic capsule. The Anterior condyloid foramen is a notch in the ex-occipital converted into a foramen by the basi-occipital. The Foramen magnum is bounded by the four distinct elements of the occipital bone—squamo-, basi-, and ex-occipitals.

These foramina are true apertures of exit for cranial nerves. The remainder may be regarded as adventitious in that they are the result of the addition of osseous elements to the primitive cartilaginous cranium. Their mode of formation also supports the opinion that nerve-foramina mark the confluence of independent ossific centres, or lie between distinct bones. Each will be considered.

The anterior ethmoid foramen, transmitting the nasal branch of the ophthalmic division of the fifth, occupies the suture between the os planum and the frontal bone. The slit beside the crista galli, which transmits this nerve to the nasal fossa, is formed by the lateral and mes-ethmoid centres.

The holes in the malar bone, for the passage of some branches of the second division of the fifth, are situated in the line of confluence of the nuclei for this bone. The malar is sometimes traversed by a persistent suture as in the well-known "os japonicum." The infra-orbital canal marks the line of confluence of the malar and maxillary centres, whilst the naso-palatine nerves pass through minute canals, formed by the

confluence of the premaxillary bones of opposite sides. The posterior palatine canal is a space between the pterygoid plates of the sphenoid, the palate, and superior maxillary bones. The spheno-palatine, as its name implies, is a notch in the palatine bone, completed by the sphenoid. The temporal branch of the fifth nerve emerges from the orbit by way of the suture between the malar and ali-sphenoid ; and the pterygo-palatine is formed by the root of the internal pterygoid plate and the sphenoid process of the palate bone.

The most instructive of all the cranial nerve foramina are those resulting from the transformation of the branchial arches.

In the case of the dog fish the essential parts are the palato-quadrate bar, which is suspended from the skull by ligaments, and the hyomandibular cartilage. This supports the Meckelian cartilage ; posterior to it is the hyoid arch, followed by the series of branchial bars.

In the human chondro-cranium we find two bars represented, Meckel's cartilage and the hyoid bar. No branchial arches behind this are developed, except the distal end of the thyroid.

The nerves chiefly concerned with the appendicular elements are a part of the fifth (trigeminal), the seventh (facial), and the ninth and tenth. The student of human anatomy knows well that these nerves run complicated courses and emit their branches in apparently extraordinary situations. The details of the modifications in the relations of the nerves in the chondral and osseous conditions of the human skull may be given as follows :—

The Fifth Nerve.—Of the various branches of this nerve, which in the adult pursue complicated courses, few follow so extraordinary a course as the nasal branch. In the osseous skull it enters the orbit by way of the sphenoidal fissure, and quits it through the anterior ethmoidal foramen. The nerve re-enters the skull, but lies outside the dura mater, and gains the nasal fossa by way of the slit beside the crista galli, and lies

between the nasal bones and the mucous membrane covering it. In the chondral skull its course is almost as direct as in the dog-fish. The complication arises in this method : the ossification of the frontal and the nasal bones separates it from the integument, so that in early life the nerve pursues its course between bone and cartilage ; gradually the pressure of the nasal bone brings about absorption of the underlying cartilage, so that eventually the nerve lies between bone and mucous membrane. The expansion of the cerebrum leads the frontal bone to encroach upon and overlap the ethmoidal region, and thus buries the nasal nerve in the process. The conclusion is obvious : from the time this nerve passes the sphenoidal fissure, although it re-enters the bony cranium, its course is strictly extra-cranial. The osseous labyrinth which hides the second division of the fifth results from the addition to the chondral skull of the superior maxilla, and need not further detain us, as the facts speak for themselves. The Vidian canal presents much that is interesting. The first suspicion that the Vidian nerve is of morphological importance suggested itself to my mind upon observing its relatively large size in the embryo as compared with its insignificance in the adult. The internal pterygoid plate is an adventitious element of the skull, which fosters itself on the sphenoid. The mode of construction of the canal is after this fashion ; the internal pterygoid plate fuses at first with the ali-sphenoid : when the latter joins the lingulum the pterygoid also anchyloses with it. The coalescence of these three elements with each other leaves a chink. The effect of this is to bury the Vidian nerve, which up to this period passed freely above the pterygoid bar. That portion of the nerve which intervenes between the geniculate ganglion and the canal, like the superficial petrosal nerves, is within the bony cranium, but outside the dura mater ; hence it is, morphologically speaking, extra-cranial.

The same line of argument applies to the inferior dental

nerve. In the chondral skull its course is simplicity itself ; but when the ossific nuclei for the lower jaw invest the Meckelian cartilage, their coalescence disguises its original simple path.

The Facial Nerve.—So long as the branchial bars retained their original function in any degree, the course of this nerve was in conformity with the remaining branchial nerves ; but on the transformation of the proximal portion of the hyomandibular cleft into a tympanum, profound modifications ensued. The extent of this modification is clearly indicated by the fact that in the chondral stage of man's skull the nerve lies in a groove on the outer wall of the periotic cartilage, and the chorda tympani flits between the hyoidean and mandibular bars. In the adult skull the complex course of both nerves is too well known to need description. It may be mentioned, however, that the stylo-mastoid foramen is bounded by three ossific nuclei ; they are the epiotic, tympanic annulus, and the tympano-hyal. The " iter chordæ anterius " is a chink between the squamosal and the tympanic elements of the temporal bone.

In the same way may we account for the otherwise perplexing passages of the tympanic branches of the glossopharyngeal and vagus nerves. In the cartilaginous periotic capsule these nerves pursue the simplest possible courses ; but when they become hidden by the tympanic bone, and embedded among the intrinsic ossification of the otic capsule, complexity displaces simplicity.

An impartial survey of the facts, which have been stated in the foregoing pages, is sufficient to show that the almost endless complications which characterise the mammalian skull must be a direct result of the evolution of the highest skull from a simpler form. The two chief factors in producing complexity are the gradual increasing volume of the brain, especially of the cerebrum, and the suppression of the branchial apparatus.

At first the cerebrum lies in the same horizontal plane as the primary vesicles ; in time it is seen to rotate backwards, and, in

the higher types, overlaps dorsally, anteriorly, and laterally the underlying vesicles. The increase in size ruptures the vault of the chondro-cranium, so that it is covered by membrane. To gain space, the enlarging cerebrum invades the facial portion of the skull and appropriates the ethmoidal region. Laterally it dips among the branchial appendages, and claims part of their territory. Hence the Gasserian ganglion and its branches, the nerves in the cavernous sinus, and the geniculate ganglion, with its petrosal ramifications, are drawn into the space between the dura mater and the middle fossa of the skull.

The opinion that the dura mater should be regarded as the limit of the primitive cranium has a pathological value as well as an anatomical import, for it serves to explain, what on other grounds would be inexplicable, the occurrence of dermoid cysts lying in the folds of the dura mater. If we remember that the integument and dura mater are actually in contact in many situations, at that period of life when formative energy is at its height, the mystery vanishes. The discussion, however, of this part of the question is foreign to the purpose of this article.

Note.—The relations of the facial nerve to the otic capsule are discussed in detail in a paper on the "Ossification of the Temporal Bone." (*Journal of Anatomy and Physiology*, 1883, xvii., 498.)

IX

CHOROID PLEXUSES, ARACHNOID TUFTS AND PSAMMOMAS

(*An Emeritus Lecture delivered at the Middlesex Hospital, February 7th*, 1922.)

The ruffle-like structures, called choroid plexuses, which float in the ventricular fluid of man's brain have aroused the curiosity of anatomists for centuries, yet they took little more interest in them than gardeners take in weeds. Of late these plexuses have acquired importance for pathologists, physicians, and surgeons.

The Choroid Plexus.

In the living brain a choroid plexus is red, for it is well supplied with blood, and the fringes floating in pools of cerebro-spinal fluid resemble the beautiful long red gills of the larva of the Alpine Salamander.

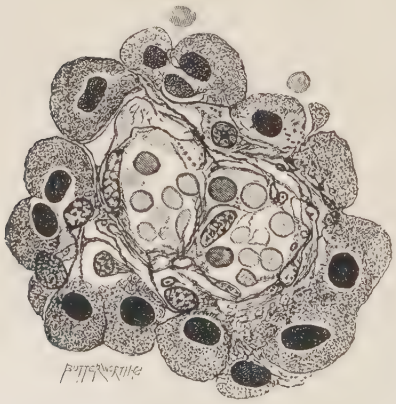

Fig. 30.—Microscopic characters of a choroid plexus (Morowoka).

Choroid plexuses are highly developed arachnoid tufts and often contain cholesterol. They are glandular organs and secrete cerebro-spinal fluid. The plexus differs in structure from secreting glands in general, the secreting cells being on its outer surface

(Fig. 30). There is convincing experimental proof that most of the cerebro-spinal fluid is secreted above the aqueduct of Sylvius.

In order to understand the relations of the various plexuses it is worth while to review their distribution. The velum interpositum with which they are so intimately connected—indeed it is the supporting structure of the plexuses—is a fold of pia mater and arachnoid, buried in the brain when the primary cerebral vesicles turn backward to envelop the primary encephalic vesicles which ultimately become the third and fourth ventricles; the middle vesicle persists as the aqueduct of

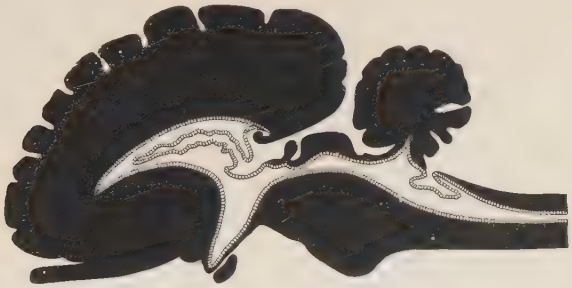

Fig. 31.—Diagram of a mammalian brain showing the distribution of the choroid plexuses.

Sylvius (Fig. 31). All parts of the velum which come in close relations with the ventricles are richly furnished with vascular fringes. These tufts reach their highest development along the edges of the velum, which extend into the lateral ventricles and their cornua. The fourth ventricle has a rich choroid plexus, and the villi are big in the lateral recesses; at the orifices of these infundibula the plexus floats in the fluid of the pool called the cisterna magna. There is a mystery surrounding the lateral recesses of the fourth ventricle. The orifice of each recess is in close relation with the slight depression in the petrosal marking the centre of the circle formed by the posterior semi-circular

canal ; this spot marks the osseous grave of the bulbus endolymphaticus. In some fishes the duct of the swim-bladder is in communication with the ductus endolymphaticus ; the communication may be direct, or through the intervention of a chain of ossicles to which classical and picturesque names have been applied—tripus, scaphium, and claustrum. Is this the remains of an old communication between the canal system of the internal ear and the intracerebral collection of fluid ?

In the horse, the choroid plexus of the fourth ventricle forms

Fig. 32.—Lateral view of the cerebellum and medulla of a horse showing a cluster of the choroid plexus around the orifice of the lateral recess of the fourth ventricle.

a conspicuous ring around the orifice of each lateral recess (Fig. 32). When the brain is removed from the skull the plexus forms a bunch concealing the opening, but if the brain be immersed in water, the orifice of the recess is easily seen. The plexus at each lateral recess rests upon the roots of origin of the glossopharyngeal and vagal nerves.

The orifices of the lateral recesses of the fourth ventricle establish communication between the ventricular cavities and the general subarachnoid spaces of the brain and spinal cord.

Arachnoid Tufts in relation to Psammomas.

Arachnoid Tufts.—The arachnoid investing the brain and spinal cord is beset with villous tufts which agree in structure with the choroid plexus—indeed, a choroid plexus is a clump of exaggerated villi growing from a fold of arachnoid in relation with a ventricle.

Though the tufts are universal on the arachnoid they are more abundant in the vicinity of the venous sinuses of the cranial dura than elsewhere. On the spinal arachnoid, the tufts cluster around the margins of the openings by which the nerve-roots quit the dural sheath. Like the choroid plexuses, arachnoid villi may grow a luxurious local clump of papillomas that lead to disastrous consequences, for they are liable to become compacted and encapsuled by exudation due to immersion in the cerebro-spinal fluid. Such tumours exert dangerous pressure on the adjacent brain, cord, or nerves. Tumours of this character are conveniently known as Psammomas. There is also another variety of arachnoid papilloma which behaves malignantly in relation to bone (see p. 119).

Psammomas.—In 1867 Virchow gave the name *Psammoma* (ψαμμος=sand) to peculiar tumours of the meninges containing cholesterol. Pathologists subsequently confirmed his observations, and the energy of surgeons in the twentieth century has made them familiar objects in pathological museums.

My interest in these tumours began in 1886, because a careful study of their histology convinced me that they arose from the choroid plexuses of the ventricles, and from the arachnoid tufts. This view is supported not only by their structure, but also by the localities in which they are found.

The notion that psammomas of the meninges arise from arachnoid tufts occurred also to Schmidt in 1902. He published a description of psammomas of the dura mater and ascribed them to Pacchionian bodies. Some new observations on these

curious bodies show that they are responsible for certain osseous tumours of the skull of a remarkable kind. The pathological behaviour of arachnoid tufts is a good example of the effects of environment on tumours. When the choroid plexuses, or a clump of arachnoid villi, grow luxuriantly they form clusters of papillomas, resembling the well-known villous tumours of the bladder, or the delicate villi of the chorion which invests the

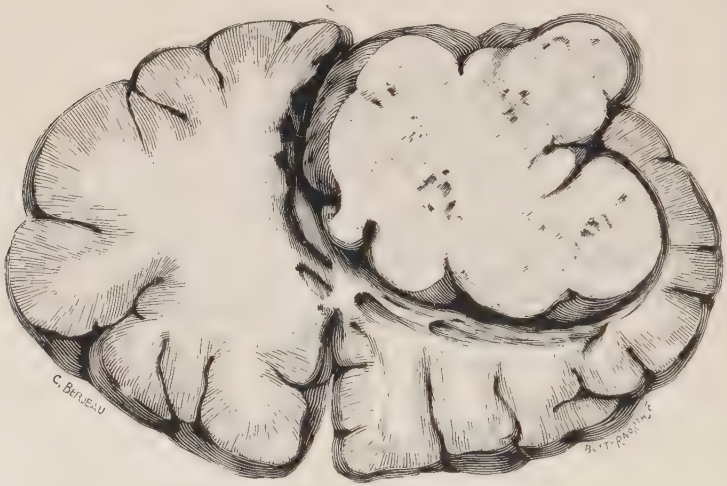

Fig. 33.—Transverse section of the frontal lobes of a brain exposing a psammoma compressing, but not infiltrating, the brain. It dipped into the longitudinal fissure as low as the corpus callosum. The tumour was covered by pia mater. Natural size. From a woman aged fifty-eight.

embryo. When papillomas arising from a choroid plexus or arachnoid tufts, are freely immersed in cerebro-spinal fluid they become coated with an exudate which not only cements the papillomas together, but encapsules them. These tumours vary in size and in shape like potatoes. Increasing in size they press on the adjacent brain and form deep bays in its substance without invading its tissue. Such tumours are not uncommon

in the neighbourhood of the falx cerebri. They grow silently and unsuspected until they occasion a catastrophe. For example : a woman, aged fifty-eight, found lying unconscious under the table of her room, was removed to the Middlesex Hospital and died soon after admission. A tumour had grown from the falx and insinuated itself into the longitudinal fissure and embedded itself in the frontal lobes, as low as the corpus callosum, without infiltrating them. It was covered with pia mater (Fig. 33).

There is great difficulty in localising some of these tumours. A man had been under treatment for "pain in the head." A liniment had been prescribed and used, but as it failed to relieve pain the man drank it, and died in consequence. An examination of the interior of the head revealed a psammoma, as big as a chestnut, growing from the arachnoid and embedding itself in the frontal lobe of the brain. It displayed to the microscope the concentric bodies characteristic of this species of tumour.

When psammomas contain much cholesterol (cholesterin) they glisten like mother-of-pearl, and this won for them the name cholesteatomas. In the course of the last 100 years a score of names has been invented for them. A critical study of the structures in which they arise—arachnoid tufts and the exaggerated tufts called choroid plexuses, has led to a clearer conception of their nature. Psammoma is an expressive, classic, and convenient label for a tumour of this kind.

On microscopic examination a psammoma resembles a cluster of papillomas embedded in dense structureless material. The sections show columns with a central core of connective tissue, and blood-vessels, with a ring of cells arranged concentrically around the core. The idea that such a tumour represents a compact cluster of arachnoid tufts, or choroid plexus, is irresistible (Fig. 34), and the histological picture is emphasised by comparing it with the appearance of a normal plexus in Fig. 30.

In fresh specimens the characteristic plates of cholesterol may be obtained by teasing.

All who make a close study of the morbid anatomy of the human body express astonishment at the marvellous adaptability of vital organs to local interference with their functions. In the central nervous system the most vital section is the medulla, especially the portion forming the floor of the fourth ventricle. Papillomas growing luxuriantly from the choroid plexus of this ventricle may choke it, like weeds may obstruct a brook: then the papillomas become infiltrated with cholesterol which cements them into a compact iridescent mass. These changes occur slowly and the adjacent nerve-tissue expands and accommodates the tumour. When it obstructs the escape of the cerebro-spinal fluid from the lateral ventricles by pressing on the aqueduct of Sylvius, the resulting hydrocephalus causes headache, dizziness, staggering gait and delirium. Suddenly, after unusual exertion the individual falls in a fit; has a succession of fits, becomes comatose, and dies.

Fig. 34.—Microscopical appearance of a psammoma.

For example, a woman, aged thirty-two, mother of six children, complained for six months of headache and staggering gait, and then died. A large psammoma filled the fourth ventricle. It gleams like mother-of-pearl (Fig. 35).

A common situation for a psammoma is the area near the

flocculus, familiar to surgeons as the cerebello-pontine angle. Such a tumour arises in the tufts of the choroid plexus as it emerges from the lateral recess of the fourth ventricle. A psammoma in this situation is loosely attached to the adjacent membranes, but by pressure it leads to grave and distressing symptoms on account of the proximity of the roots of the trigeminal, facial, auditory and vagal nerves, and the medulla. Psammomas arising in relation with the choroid plexus of the

FIG. 35.—Cerebellum, pons and medulla. The fourth ventricle is occupied by a median psammoma, glistening like mother-of-pearl. From a woman aged thirty-two. (Museum, Royal College of Surgeons.)

fourth ventricle may be unilateral, bilateral, or median. In dealing with them surgeons have had brilliant success.

A glance at the tumour (Fig. 35) and its environment would almost suggest that it was beyond the reach of even the most venturesome surgeon! Even here surgical courage coupled with skill has won.

In 1921 a butcher, aged fifty, complained of headache and dizziness for nearly thirty months and then he had a fit of

unconsciousness. Careful examination led to the diagnosis of a tumour in connection with the cerebellum in the median line. The parts were exposed by a median vertical incision involving the occipital and the arches of the atlas and axis. A white glistening tumour was found filling the fourth ventricle. It was enucleated without difficulty. The aqueduct of Sylvius was greatly dilated and the tumour had produced an obstructive hydrocephalus. The man recovered, and left the hospital on the eighteenth day. A year after the operation he was quite well with the exception of a little ataxia when he " walks rapidly upstairs " (E. Sachs).

Psammomas of the spinal arachnoid are singularly uniform in shape and size. They are often removed with good consequences immediate and remote.

Sheer curiosity is an inducement to give a list of names applied to meningeal tumours during the last 100 years by writers including Cruveilhier, Virchow, Paget, Billroth, Lebert, Robin, Golgi, and Minot :—

Fungus of the dura mater. Cancerous tumour of the meninges. Epithelial cancer. Fibro-plastic tumours. Myeloid. Cylindroma. Epithelioma. Psammoma. Cholesteatoma. Sarcoma of the dura mater. Alveolar sarcoma. Angiolitic sarcoma. Alveolar endotheloid sarcoma. Fasciculated sarcoma. Arachnoid fibro-blastomas. Endothelioma. Dural-endothelioma Perithelioma. Mesothelioma. Meningioma. Papilloma, etc.

Very little effort has been made to associate the tumours to a particular menix, but it is quite clear that all primary epithelial tumours within the cranium arise from the arachnoid and the choroid plexuses. The epithelial element of the velum interpositum is derived from the arachnoid constituent of this curious structure.

X

PACCHIONIAN TUMOURS AND CRANIAL EXOSTOSES

Villi of various kinds play a part in our lives usually for good; sometimes for evil. Embryologists and pathologists were surprised to learn that the delicate villi of the chorion embed themselves in the endometrium to form the fœtal part of the placenta. Occasionally their erosive power enables them to pierce the uterine wall and peer into the peritoneal cavity. It was a greater surprise to learn that such delicate structures sometimes acquire malignant power and penetrate blood-vessels. Fragments detached from such villi become emboli and lodge in distant organs, embed themselves and establish new tumour colonies. This disease of the villi, now well recognised, is described as chorionic cancer, and the primary mass in the uterus may be big enough to make it appreciable in the hypogastrium.

It is well known that the pits in the cranial vault, familiar to students of human osteology as the foramina for the Pacchionian bodies, are due to the erosive action of arachnoid tufts; but it is a recent discovery that these villous bodies sometimes grow luxuriantly, overrun the adjacent bones, and produce in them extraordinary changes.

In 1885 Sir William Stokes described the skull of a male Cingalese (Fig. 36), and on the vault of this skull there is a mass of bone resembling a crown of loosely compacted coral. The tissue of this crown is intimately incorporated with the vault of the skull, and the whole mass is permeated with neat vertical

pits. Each "pit" is really a tunnel, and as neat as a Pacchionian pit. These tunnels are exaggerated Pacchionian pits produced by pathological arachnoid tufts. Professor S. G. Shattock has made a thin transparent section of the crown, and

FIG. 36.—Skull of a male Cingalese, aged twenty. The vault of the skull resembles a crown of loosely compacted coral. The mass is traversed by hundreds of tunnels—exaggerated Pacchionian pits—which open on the surface. The orifices are represented, for the sake of emphasis, too big. The bony mound on the skull is the skeleton of a Pacchionian tumour. (Museum, Royal College of Surgeons.)

the tunnels can be seen traversing it completely. There are hundreds of tunnels in this crown, and they recall holes in ship-timber bored by the teredo or those in limestone made by whelks (Pholas).

In recent and unmacerated hyperostoses of this kind arachnoid villi can be demonstrated in the tunnels. In the head of the patient there was a layer of gelatinous material over the bone, between it and the scalp ; it also filled the tunnels. The dura adhered to the bone and to the surface of the brain.

When this extraordinary specimen was described by Stokes no one had the least suspicion that such a change could be produced by arachnoid villi. Dr. W. G. Penfield, in 1921, began a careful study of the intra-cranial tumours preserved in the museum of the National Hospital for the Paralysed and Epileptic, Queen Square, London. He has proved that the soft tissue of the tumour arises within the cranium, erodes the dura, involves the overlying bone, and causes a complete rearrangement of the osseous structure. The bone-forming elements lay down bone in the substance of the neoplasm. The action of the tumour elements leads to complete rearrangement of the osseous tissue between the tumour and the scalp. The osteogenetic activity is greatest in the pad of tumour-tissue that lies between the skull and scalp. Thus the bone forms on the external surface and may become very large and hard. It is a singular clinical feature, in many of the patients, that the presence of the hard sessile boss of bone was the first sign of disturbance. In some the first symptom is intense pain beneath the bony boss. In such patients epileptic seizures are common. In a few instances the tumour has been attributed to an intensive local injury, such as a blow upon the head.

Mr. Zachary Cope gave me an opportunity of examining a man with a smooth sessile hyperostosis of the frontal bone associated with epileptic seizures (Fig. 37). Cope excised the osseous lump and removed with it a flattened, yellow, gelatinous plaque of tissue characteristic of these tumours. The man recovered and the seizures completely abated. The histology of the plaque recalls in a striking way that of chorionic cancer.

In addition to the skull of the Cingalese the museum of the

Royal College of Surgeons contains a similar and equally remarkable example obtained from a miner, who died in the General Infirmary, Leeds, 1904. Eleven years previously he fell backwards and bruised his head. The bruise did not subside and continued to increase. The man complained of headache and occasional diplopia. With the hope of arresting the growth of the tumour the left external carotid artery was tied, but death followed the operation in ten days. The hyperostosis involves the left parietal adjacent parts of the occipital, and the squamous portion of the temporal. For the most part the normal tissue has been replaced by exceedingly dense bone, and a plaque-like portion extends within the skull. The dura adhered to this part of the tumour (Fig. 38).

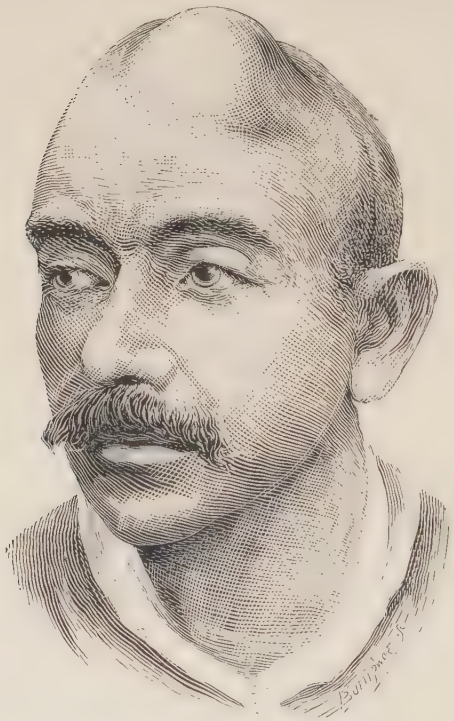

Fig. 37.—Pacchionian tumour involving the frontal bone. Zachary Cope's patient.

It is curious on examining osteomas of the skull, formed under these conditions, to find that the surface immediately in relation with the dura assumes the form of an ivory-like plaque, whilst the mound on the vertex, in relation with the scalp, consists of porous bone freely permeated with tunnels. Normally the inner

table of the skull bones differs so markedly from the outer, on account of its ebumation, that it received from anatomists

FIG. 38.—Portion of the base of a skull to the left of the middle line showing, in section, an immense hyperostosis. F, frontal; P, petrosal; O, occipital; F.M., foramen magnum. (Museum, Royal College of Surgeons.)

the distinctive name of vitreous table. It is noteworthy that in the transformation effected by Pacchionian tumours, the

intra-cranial portion of the osseous matrix is, in its physical features, like unto the vitreous table.

Skulls changed in this way could not escape the observations of pathologists. Some examples have been described by French writers as hemicraniosis. The frontal is the bone of preference, but the parietal and squamosal are often involved. The relationship of cranial hyperostosis to meningeal tumours has also

Fig. 39.—Coronal section of the frontal region of the head, showing a Pacchionian tumour growing from the arachnoid, permeating the frontal bone. (Museum, St. Bartholomew's Hospital.)

been considered by American surgeons—Spiller and Cushing among others.

The relationship of an arachnoid tumour to the osseous elements is well shown in a specimen preserved in the museum of St. Bartholomew's Hospital (Fig. 39). The patient was under the care of Sir James Paget. A section prepared for the microscope, contained in the museum cabinet, shows well the villous nature of the tumour.

The merit of Penfield's excellent essay is his demonstration of the soft tissues which fill the tunnels in the cranial hyperostosis, and I enjoyed the privilege of examining the specimens he prepared for microscopic investigation.

Penfield prefers to use the name "endothelioma" for these tumours; but names are only convenient labels, and in this case matter little if we keep in mind this important fact: The epithelium, and the associated soft tissues lodged in the tunnels of the osseous bosses, spring from the arachnoid—*they are, in fact, abnormal arachnoid villi.* When examined in sections these exaggerated villous tufts embedded in osseous tissue resemble fossil ferns in clay or shale. The bony edifice on the skull recalls the huge mounds built by termites in tropical forests.

These observations are of importance and throw new light on so-called cranial osteomas. It is probable that similar tumours starting in arachnoid tufts near the basal venous sinuses may involve the adjacent cavities such as the orbit, frontal sinus, pharynx or tympanum. It is also a fair presumption that in some instances, tumours supposed to have arisen in the orbit, or pharynx, and invaded the skull, may have started in the arachnoid villi and crept into adjoining cavities, especially the orbit. These tumours are as striking in their clinical features as in their histology that much attention is sure to be devoted to them. The name Pacchionian tumours will serve for a convenient label.

The formation of bone by such delicate structures as arachnoid tufts, under pathological conditions, is a matter of importance. It is well-known that sarcomas of bone often contain osseous tissue, not only in the primary tumour, but in the secondary deposits. Bone formed under such conditions may be a lump as big as a fist. In some specimens it takes the form of osseous prisms at right angles to the periosteum. There are excellent examples in the museum of the Middlesex Hospital. Ossifying sarcomas are usually found connected

with the long bones of the limbs, but they are not rare on the scapula, ilium, and ischium. It was long believed that ossific deposits in sarcomas on long bones were due to the activity of the periosteum, but Knaggs has shown that they occur also in endosteal sarcomas, the active agents in the ossification being the sarcoma cells. The surest evidence is furnished by sarcomas arising in a soft organ like the breast. I have reported an undoubted example of a mammary sarcoma which contained a lump of true bone as big as a golf-ball.

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XI

THE CHOROID PLEXUSES AND VENTRICLES OF THE BRAIN AS A SECRETING ORGAN

(*An Address to the Students of Anderson College, Glasgow, March*, 1923.)

Although my theme is a morbid condition of the brain, I propose to set before you a parallel in pathology connected with the kidney which may help to explain the remarkable nature of the ventricles of the brain.

A Pathological Parallel.

The kidney is a compound gland which strains liquid from the blood. This liquid—urine—charged with products, secreted by the epithelium lining the uriniferous tubules, collects in the pelvis of the kidney and is conveyed by the rhythmic muscular action of the ureters to the urinary bladder, from which it is discharged at convenient intervals. Occasionally the escape of urine from the ureter or from the bladder is hindered, and this hindrance leads to its accumulation in the excretory duct—the ureter, pelvis, and calyces of the kidney—and as they distend the pressure causes the kidney to be gradually converted into a multilocular sac. Coincident with this distension, the muscular tissue of the ureter and the glandular tissue of the kidney slowly disappear. This end-result is known as hydronephrosis. Kidneys are often converted into sacs of this kind before birth. Ante-natal hydronephrosis proves that kidneys are functional

in the late stages of fœtal life, and this lends support to the opinion that the bath of amnionic fluid, or hydrosphere, in which the fœtus floats contains urine.

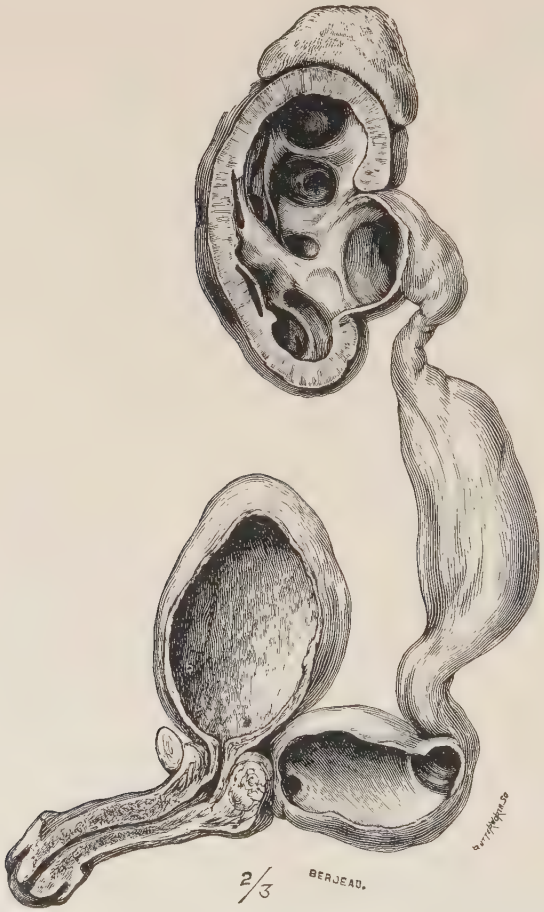

Fig. 40.—Urinary organs and right adrenal of a new-born boy; they show the disastrous effects of ante-natal hydronephrosis.

The damaged urinary organs shown in Fig. 40 belonged to a male infant that only survived its birth a few days. They are represented by a sacculated kidney and a greatly dilated ureter on the right side. There is a small circular perforated diaphragm where the ureter opened into the bladder, but it offered no obstruction to the flow of water from the ureter into the bladder when tested. There were no traces of the left kidney or its ureter. Retention and slow accumulation of urine had destroyed the glandular tissue of the kidney and rendered the boy unfit to live.

Hydrocephalus.

Recent researches into the physiology of the choroid plexuses of the brain prove that they act as glands, and the secretion they furnish is known as cerebro-spinal fluid. These plexuses grow luxuriantly from the surfaces of the velum interpositum in relation with the ventricles of the brain. They are vascular, covered with a single layer of epithelium, and differ in construction from glands in general in having the secreting cells on the surface of the plexus. Experimental evidence indicates that the bulk of the fluid is secreted above the aqueduct of Sylvius. The fluid secreted by the choroid plexuses collects in the cerebral ventricles, and the narrow canal, or iter, which tunnels the corpora quadrigemina establishes communication with the fourth ventricle. The fluid escapes by means of the lateral recesses into an irregular space at the base of the brain, and forms a pool called the cisterna magna.

The cerebro-spinal fluid occupies the arachnoid spaces of the brain and spinal cord, and exists under considerable pressure. There is no external orifice for the discharge of the fluid, and the evidence available indicates that it is absorbed by veins. Regarded as a secretion, the cerebro-spinal fluid exists under peculiar conditions, and it is formed in late fœtal life. Interference with its escape from the ventricles causes the retained

fluid to produce changes on the brain which are parallel with those seen in hydronephrotic kidneys.

When both lateral recesses of the fourth ventricle are occluded

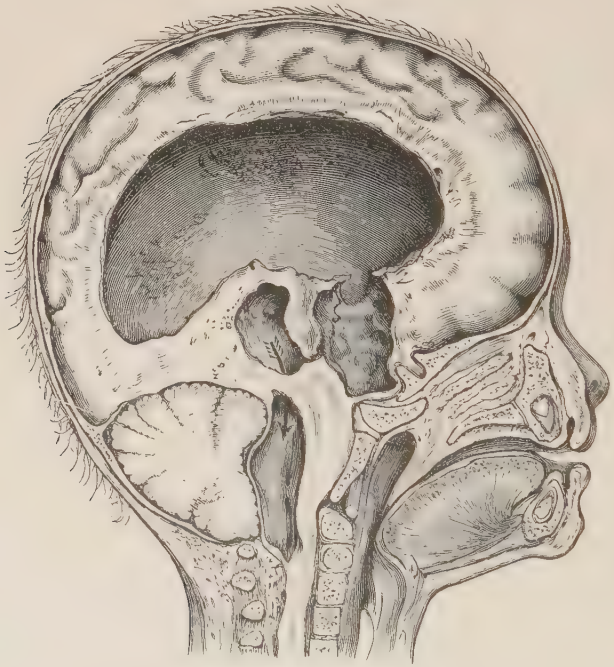

FIG. 41.—Sagittal section of the head of a hydrocephalic child. The head of the arrow is in the fourth and the feathers in the third ventricle. The lateral recess is occluded. The infundibulum is widely dilated, the pituitary fossa expanded, and the hypophysis flattened. (Museum, Middlesex Hospital.)

in fœtal life the effect on the brain is disastrous. In the head of the child shown in sagittal section (Fig. 41) the lateral ventricles are dilated and form a common cavity with the third which is many times larger than normal; the infundibulum is also

involved and so distended that it has flattened the hypophysis into a thin wafer. The fourth ventricle is dilated, the vermiform process of the cerebellum is effaced, and the choroid plexuses, the secreting elements, have vanished. The brain of this child has been as surely damaged by the pressure exerted by the slow accumulation of retained cerebro-spinal fluid as

Fig. 42.—Brain in sagittal section showing great distension of the ventricles secondary to occlusion of the lateral recesses of the fourth ventricle. From a man aged twenty-nine.

renal tissue in advanced hydronephrosis. Like the hydronephrotic boy, this hydrocephalic child survived its birth only a few days. The difficulty in investigating congenital hydrocephalus arises from the softness of the brain, especially in the fœtal stage. The occlusion of ducts and passages is a common and inexplicable event in fœtal life.

In the parallel examples of kidney and brain the organs were

destroyed during fœtal life and rendered post-natal life impossible. Minor degrees of such changes in kidneys, or in the brain, are not incompatible with life. Many years ago I urged that examples of extreme hydronephrosis found in adults for which no adequate cause could be assigned were due to causes acting during fœtal life. This is certainly true of hydrocephalus. Changes beginning before birth may progress with extreme slowness after birth. Here is an example :—

A baker, aged twenty-nine, was admitted into the Royal Infirmary, Edinburgh, for fits and other symptoms indicating intra-cranial pressure. He was submitted to a decompression operation. At the end of a month the symptoms returned and an attempt was made to establish permanent drainage, but he died thirty-six hours later. The brain was preserved and carefully examined by Mr. J. N. J. Hartley, who gave me facilities for examining it and obtained some excellent photographs. The brain is shown in sagittal section (Fig. 42). The ventricles are greatly distended and the choroid plexuses atrophied. The choroid plexus of the fourth ventricle is obliterated. The third ventricle is converted into a globular cyst which bulged into the circle of Willis, and separated the optic chiasma and the carotid arteries ; it also flattened out the hypophysis. *Each lateral recess of the fourth ventricle* is completely blocked by a thin diaphanous membrane which juts out like a stunted cone near the flocculus, and separates the roots of the big nerves which lie in this region of the medulla. The occluding membrane is best displayed at the right recess (Fig. 43).

Occasionally unilateral occlusion of a recess is followed by the formation of a cyst, the size of a cherry, and a fringe of choroid plexus floats in the fluid which distends it. Such a condition is sometimes called hydrocele of the fourth ventricle. Unilateral occlusion does not lead to hydrocephalus, but such a cyst has produced facial palsy, deafness, anæsthesia of the corresponding side of the face, and other symptoms referable to

pressure on the roots of the great nerves connected with this important region of the brain.

Morowoko made a careful microscopic investigation of the choroid plexus in patients dying from general paralysis of the insane. He suggests that the choroid plexus in fœtal life exercises its functions, and confirms the view that the choroid gland may be regarded as the main producer and regulator of

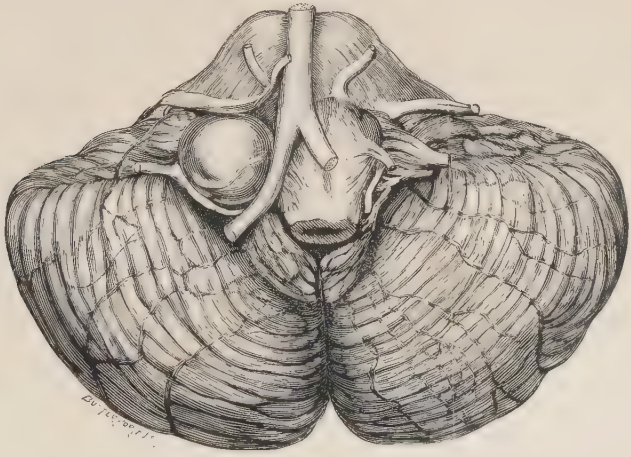

Fig. 43.—Under surface of the cerebellum of the brain represented in Fig. 42, showing occlusion of the lateral recesses of the fourth ventricle.

normal cerebro-spinal fluid; it is the filter of toxic products and passes into the blood the toxic waste products of the nervous system.

In addition to the fluid secreted by the choroid plexuses there is a complex gland which discharges secretion into the third ventricle—*i.e.*, the hypophysis. It is regarded by physiologists as a ductless gland. I feel sure the infundibulum acts as a duct to the hypophysis; some of its products escape into the third

ventricle and mingle with the cerebro-spinal fluid. Occasionally the third ventricle is occupied by colloid stuff, perhaps pseudo-mucin, which when seen after death resembles jelly, but after the brain has been immersed in hardening solution it assumes an appearance like softened glue. These gelatinous masses have been described as sarcomas of the third ventricle ! Dr. J. Goodwin Greenfield showed me one and shrewdly suggested that this colloid stuff is a pathological fluid discharged into the ventricle from a disordered hypophysis.

Tumours.

The ventricles of the brain with the choroid plexuses not only agree with the kidney, in principles of construction and function, but in their liability to epithelial tumours. The comparison of the kidney with the cerebral ventricles does not end merely with the effects produced by obstruction to the escape of the secretion, but there is striking agreement in the methods of obstruction. A choroid plexus resembles in principle the Malpighian corpuscle of the kidney, in which a single layer of epithelium covers a vascular coil ; the secretion is discharged into the convoluted portion of the uriniferous tubule.

Epithelial membranes are liable to grow papillomas, and when growing luxuriantly in a narrow conduit a clump of papillomas is a very serious obstruction in the adits either of the brain or of the kidney. It is established by the experiments of Dandy and Blackfan that the greater part of the cerebro-spinal fluid is secreted above the aqueduct of Sylvius, and the experimental blockade of this adit leads to rapid and fatal hydrocephalus. Clinical observations agree with the experimental results. The escape of fluid from the lateral ventricles can be hindered by tumours in three situations—at the entrance and at the exit of the aqueduct, and by simultaneous occlusion of the lateral recesses of the fourth ventricle.

The most instructive and impressive examples arise in connection with the fourth ventricle. The posterior half of the roof of this cavity is very rich in villi ; when they transform into papillomas the cavity may be so stuffed with them that the aqueduct of Sylvius is effectually obstructed and the fluid accumulating in the lateral ventricles distends them. The narrow aqueduct in such circumstances may be dilated until it is as big as a goose-quill. The symptoms associated with such conditions are as tragic as simultaneous obstruction of both ureters, but less amenable to surgical treatment.

The most remarkable form of tumour obstruction is caused by bilateral tumours arising in the choroid plexuses as they emerge from the lateral recesses of the fourth ventricle. These picturesque tufts float in the cerebro-spinal fluid of the cisterna magna ; when the tufts grow abnormally and form clumps of papillomas, they become smothered in fibrinous exudation which not only cements the papillomas together, but encases them in a compact mass, the outer part of which is often stratified like the layers of an onion. When such tumours are examined microscopically, the papillomas, in section, are represented by circular bodies ; the centre of each contains blood vessels and tissues in various stages of degeneration. The tissues are infiltrated with cholesterol ; in some tumours this substance is so abundant that the mass gleams like mother-of-pearl ; they are often called in consequence cholesteatomas and psammomas (sand-tumours). These tumours do not so effectually blockade the ventricle as papillomas occupying the fourth ventricle, but they lead to grave and fatal consequences (see Fig. 35, p. 115).

There is a rare variety of tumour which arises from the infundibulum and blocks the inter-ventricular communication by pressure on the corpora quadrigemina (Fig. 44). The tumour, which equals a walnut in size and resembles it in shape, grows from the infundibulum and bulges into the third ventricle.

The hypophysis preserves its size and shape, but is intimately associated with the tissue of the tumour. The third and the lateral ventricles of the brain are much dilated because of the accumulation of cerebro-spinal fluid. The obstruction was

FIG. 44.—Hypophyseal-duct tumour. The brain in sagittal section. The infundibulum is replaced by a tumour which pressed on the quadrigeminal bodies, closed the Sylvian aqueduct, and led to distension of the lateral and third ventricles. Semi-diagrammatic. (Museum of the Middlesex Hospital.)

caused by the pressure of the tumour on the corpora quadrigemina closing the aqueduct of Sylvius.

Tumours of the infundibulum have been reported by Erdheim (1904) and Strada (1911). They have a peculiar structure and resemble very closely that of an epithelial odontome, but for the moment I am mainly concerned with the manner in which

these tumours interfere with inter-cerebral communications and also set up curious symptoms, some of which are recognised as sequential to damage of the hypophysis.

Foramen of Magendie.

In text-books of anatomy reference is made to a hole in the membranes at the apex of the calamus scriptorius which marks the lower end of the cavity of the fourth ventricle. This hole, called the foramen of Magendie, is supposed to be the means by which cerebro-spinal fluid escapes from the ventricle into the subarachnoidean space. In 1879 I satisfied myself by repeated examination of the brain *in situ* that the foramen was made in the course of dissection.* I have made many examinations since that date and have satisfied myself that it is an artefact. Cleland writes in regard to the foramen of Magendie, " it can be easily demonstrated to be artificial if the dissector is on his guard."† This foramen has had such charm for teachers that it maintains a place in text-books, although sealed up by practical anatomists many years ago.

Modern knowledge of the cerebro-spinal fluid justifies the following summary. The ventricles of the brain serve as temporary receptacles for the fluid secreted by the choroid plexuses ; also some secretion from the hypophysis. The fluid escapes through the lateral recesses of the fourth ventricle into the arachnoid area for absorption.

Cerebro-spinal fluid is physiologically useful. Its excessive accumulation does not lead to toxic symptoms, but its retention in gross quantities leads to disaster from pressure effects. The unrestrained escape of the fluid is quickly fatal in children. In the variety of spina bifida called myelocele the central canal of the cord and the dural sheath open on the skin in the lumbo-sacral region ; many fœtuses with this defect are stillborn, and those born alive rarely live more than a few days. In

children persistent leakage of the cerebro-spinal fluid is incompatible with life.

Complete obstruction of the inter-ventricular communication, in children and adults, is as inimical to life as complete obstruction of both ureters.

* *Lancet*, 1881, i., 545.
† "Human Anatomy," 1896, p. 608.

XII

THE HABITS (ECOLOGY) OF TUMOURS

(*An Address to the Cambridge University Medical Society, November 7th*, 1923.)

Writings which attempt to define the term "tumour" make a big literary rubbish heap. The name though undefinable is applied to a hotch-potch of morbid conditions. A mouse is a mammal, so is an elephant—they have features in common. Many morbid conditions called tumours have sufficient features in common which permit them to be classified for descriptive purposes, for clinical study, and for treatment, but in size and habits they vary as much as mice and elephants.

Tumours are of importance to surgeons because of their harmfulness to the individuals on whom they grow. Nearly all make life uncomfortable; many shorten life. Surgeons do their best to get rid of them and study their habits (ecology) in order to acquire increased proficiency in this respect.

The microscope taught us that the tissues of tumours do not differ from those normal to the body, and with the assistance of embryology the investigation of tumours has become for many an attractive study. Embryology has provided the key to many pathological riddles. I vainly imagined that it would help to solve the problem of the origin of tumours, and a large part of my leisure for many years was devoted to this quest.

I shall endeavour to show how the life-history of a tumour

corresponds with that of the parent organ. Tumours pass through a period of growth, attain maturity and in some instances exercise the same function as the parent organ ; and this exercise by increasing their bulk leads to their discovery. The statement that tumours exercise no function is grossly erroneous.

The tissues of tumours do not differ in their habits (ecology) from the normal tissues of the body.

Take, for example, hyaline cartilage. When this tissue assumes the form of a tumour its naked-eye and microscopic characters are identical with normal cartilage. It often calcifies, and becomes converted into bone. Like cartilage covering the articular end of a bone, it may be smooth and glistening ; if submitted to friction a synovial membrane forms over it, constituting a gliding capsule ; the space enclosed by the capsule may become distended with synovial fluid. Many instances are known in which a bursa of this kind, formed over an exostosis, has contained loose bodies in every respect resembling the familiar joint-mice of normal articular cavities. Exostoses of long bones repeat the phases of development common to such bones, and during growth are capped with cartilage which behaves like an epiphysis ; the growth of the exostosis ceases with that of the skeleton.

Tumours not only agree in structure with the tissues of the organs in which they arise, but they conform to the habits of the parent organ.

Composite odontomes are tumours derived from the germs of teeth and conform to the ecology of teeth. Ensconced in the jaw an odontome grows in silence. In due time this quiescence is disturbed and the tumour manifests its relationship to teeth by erupting. The chief signs are swelling of the gum and pain such as accompanies the cutting of teeth. These troubles lead to its discovery, which usually ends in its extraction. Some superstitious persons will not submit to its extraction ; even

then the natural process is triumphant, for the tumour may fall out spontaneously, or, in spite, the patient spits it out! In a few instances an odontome has erupted and taken its place in line with normal teeth and been used in mastication. This has happened to men and horses.

Tumours in hollow viscera can excite them to action.

A tumour growing from the walls and projecting into the cavity of a hollow muscular organ can excite its muscular tissue to contract. A fibroid, a lipoma, or a cluster of warts growing in the gastro-intestinal tract stimulates propulsive movements leading to invagination of the intestine. Many astounding examples have been recorded. A submucous fibroid growing in the gastric wall near the œsophageal opening has been propelled through the pylorus into the duodenum, invaginating the parts with fatal consequences. Invagination of the small intestine is often caused by a sessile tumour. The persistent propulsive action of the muscular tissue converts sessile into stalked tumours. The contractions of the gut excited by a polypus are declared by painful sensations called cramps.

An old woman had a tumour, the size of a walnut, protruding at the anus. A surgeon of experience cut it off and was surprised to see the vermiform appendix. The tumour in this case arose on the margin of the ileo-cæcal valve and induced invagination of the whole colon.

The efforts of the uterus to extrude a submucous fibroid may be so vigorous that the organ inverts A pregnant uterus in its endeavours to expel the placenta sometimes turns inside out. The ovaries and Fallopian tubes occupy the peritoneal pouch formed by the inversion.

A tumour can initiate functional activity in an organ.

A submucous fibroid can imitate pregnancy so successfully as to deceive experienced practitioners. When an oösperm embeds itself in the endometrium, the uterus, in the course of a few months, is converted from an organ weighing 2 to 3 ozs. to

one weighing 2 to 3 lbs., with a capacity of one gallon. At the end of 280 days the slow rhythmic contractions of the uterus, stimulated by the growing fœtus, ultimately become so powerful that they expel the fœtus, the placenta, and the membranes which contain the fœtal excrementitious products. When pregnancy occurs in the rudimentary horn of an imperfect uterus or in a Fallopian tube, the fœtus cannot escape from its mother and is mummified ; in course of time it becomes converted by the deposit of lime salts into a lithopædion.

After a successful pregnancy the uterine tissue undergoes an autolytic change (which means it is transformed into soluble nitrogenous extractives) and slowly shrinks to nearly the same size and weight of an unimpregnated uterus. Similar changes may be observed in a uterus occupied by a submucous fibroid. As the tumour grows the uterus enlarges uniformly and as it rises in the hypogastrium becomes easily obvious on examination. When the tumour is soft and grows rapidly a murmur is audible on auscultation. The uterus persistently endeavours to expel the tumour and sometimes succeeds in forcing it into the vagina. This success is accompanied with painful spasms and bleeding so like a miscarriage as sometimes to deceive the medical attendant or a midwife. As a rule, the uterus fails to expel the fibroid and it slowly enlarges year by year, then ceases to grow, slowly dies, and is mummified, and in many cases calcified. A calcified fibroid resembling a block of coral, and a lithopædion may be found in pathological museums and in disused graveyards.

Submucous fibroids, especially when complicated with pregnancy, undergo autolysis, and this process will reduce a submucous fibroid the size of a fist to the consistence of soft soap in two weeks. The comparison between the ecology of a submucous fibroid and normal pregnancy is emphasised when the fibroid stimulates a large corpus luteum to form in the ovary and mucous fluid exudes from the nipples.

Tumours of Glandular Organs.

Tumours of glandular organs are often functional.

Take, for example, an adenoma of the breast. This is a collection of mammary tissue isolated from the main secretory tissue by a firm capsule which cuts it off from the excretory ducts of the breast. Such a tumour in the breast of a pregnant woman takes on its share of lactation in due course, but as there are no ducts permitting the fluid to escape it accumulates in the glandular acini and the pressure of the fluid causes atrophy of the secreting epithelium, dilatation and coalescence of the distended acini, and the formation of cavities. Such an encapsuled collection of fluid is known as an adenocele, and when large enough to attract the attention of a surgeon is, as a rule, excised.

A lobe of mammary tissue occasionally becomes detached from the axillary margin of the breast. Such a glandular islet has no excretory duct, but it enlarges during lactation in concert with the main gland and slowly declines when lactation ebbs. These islets are known as accessory breasts, but a similar islet in the substance of the breast would rank as an adenoma or a cyst.

Similar cystic tumours form in the liver in connection with the minute bile ducts. Paul proved long ago that adenomas of the liver are clumps of encapsuled biliary ducts. The cells of such adenomas are functional and the cystic spaces contain bile. The solitary (non-parasitic) cyst of the liver, though rare, belongs to this set. Some of these cysts have been so large in women as to have been mistaken clinically for ovarian cysts. In such examples as have been examined microscopically the walls of the cyst contained minute bile ducts. I have satisfied myself that these large cysts arise from the dilatation and fusion of the minute biliary ducts unconnected with obstruction to the main bile ducts. It is certain that the parts concerned in the formation of such cysts have continued to exercise their function, for they contain bile.

As in the case of the mammary gland, an isolated lobe of liver attached to the liver by a fibrous band is called an accessory lobe of the liver, but a similar islet of hepatic tissue in the substance of the liver is called an adenoma, and may become a cyst by the accumulation of its own secretion—bile.

We owe to von Eiselsberg an account of a remarkable illustration of this habit of glandular tumours. Billroth in 1886 extirpated a goitrous thyroid from a woman aged thirty-eight. The operation was followed by myxœdema. A year after the removal of the thyroid the patient passed through a normal pregnancy ; subsequently a tumour appeared in the upper part of the sternum, and as it increased in size the myxœdema disappeared. In 1892 the sternal tumour was as big as a fist and resembled a sarcoma. As it was incorporated with the bone von Eiselsberg removed it with the aid of a chisel and hammer. In structure it resembled an ossifying columnar-celled carcinoma and contained colloid material. The woman made a good recovery, but the symptoms of myxœdema recurred in the same order as after the thyroidectomy and persisted.

The thyroid gland, possessing no excretory duct, is very liable to have portions of its secreting tissue isolated, and these, becoming encapsuled and slowly enlarged by the accumulation of colloid material, form thyroid cysts and tumours, some of which attain an astonishing size.

The cell-elements of primary and secondary cancer of the pancreas can produce ferments identical with or similar to those furnished by the normal cells of the gland (Waring). The active interest taken by physiologists in the function of the pancreas, especially in relation to glycosuria, has led to some valuable experimental work. In 1892 von Mering and Minkowski succeeded in completely removing the pancreas from living dogs. In man this is an impossible operation on account of its intimate relations with blood-vessels and nerves. In dogs complete removal of the pancreas is followed in a day or two by glycosuria.

Hédon confirmed the experiments (1892) and succeeded in transferring a piece of the tail of the pancreas into a subcu-

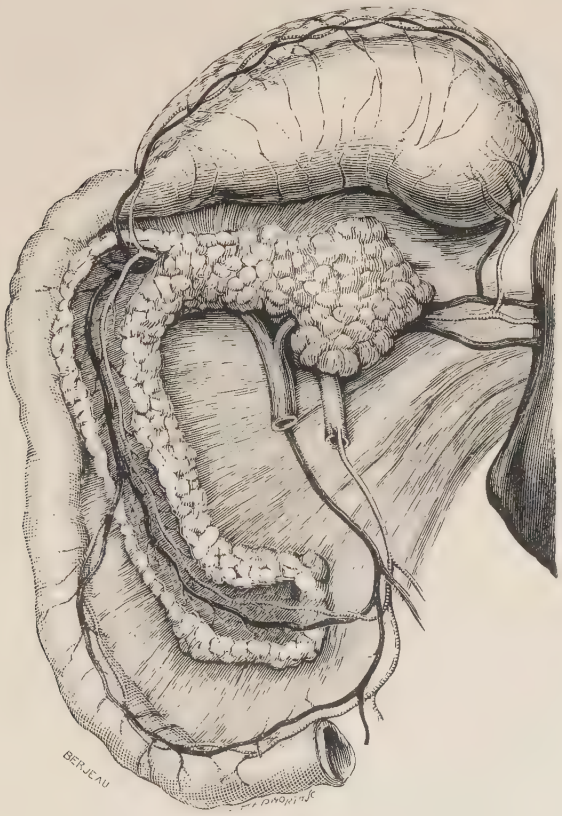

Fig. 45.—Pancreas of a dog, to show its environment (Hédon)

taneous pouch to one side of the linea alba, but retaining its intra-abdominal connections. When the graft is well established the remainder of the pancreas is completely removed and

glycosuria does not ensue. Later if the graft is excised glycosuria quickly follows. If the intra-abdominal vascular connections of the graft are obliterated the graft scleroses and disappears; under such conditions glycosuria quickly becomes manifest. Hédon notes that after the graft is transformed to an artificial subcutaneous pouch, a fistula persists for a time and pancreatic fluid issues from it.

The skill and care required to remove completely a dog's pancreas successfully is appreciated by surgeons who have performed operations on the pancreas of man. The intimate connections of the pancreas with the duodenum in dogs is shown in Fig. 45.

Colloid Omentum.

Extraordinary examples of functional activity in cancerous epithelium may be studied in the gastro-intestinal canal. The mucous membrane of this tract contains cells that secrete mucus. In the stomach the cell-covering is almost entirely formed of them; in a cell swollen with mucus the nucleus is pushed towards the basement membrane. When the mucous membrane is cancerous, the epithelial cells often furnish large quantities of mucus, which infiltrates the omentum and converts it into a gelatinous mass, commonly called "colloid omentum." The mode in which this change is produced can be explained, and my knowledge of it has been obtained in the course of operations performed on the stomach for the relief of gastric disorders.

When the stomach contains a focus of cancer the cylindrical cells, heavily charged with mucin, permeate its wall, fall into the lesser bag of the peritoneum, engraft themselves, and appear, in the early stages, as small yellow flakes. At this stage microscopic examination shows them to consist of clumps of columnar cells full of mucin. These pathological or secondary foci of cancer act as glands and shed mucus in abundance into

the omental fold. Such foci multiply, and being reinforced by cell-showers from the primary focus invade the omentum and convert it into a mass of "colloid" weighing many pounds. Omentum changed in this way sometimes forms such a large mass that it has been mistaken in women for a big ovarian tumour. It is not uncommon when cell-showers of this kind fall from a primary focus in the stomach, or the colon, for the epithelium to engraft itself on the ovaries and convert them into colloid tumours as big as coco-nuts. Implantation tumours of this kind are by no means rare, and as they are now appreciated by surgeons there is little danger of such enlargements, secondary to primary cancer of the stomach or colon, being mistaken for primary ovarian tumours.

I have considered these conditions especially because, in dealing with the large multilocular glandular tumours of the ovaries, there is a possibility of error unless care is taken in the microscopic examination of the tumour.

Ovarian Dermoids.

Dermoids have an irresistible attraction for me. They prove that many tumours owe their grossness to the accumulation of retained secretions.

The simplest example is a sequestration dermoid on the face or scalp. This takes the form of a globular tumour with a central cavity lined with skin furnished with dermal elements—epidermis, sweat glands, hair bulbs, sebaceous glands. In such tumours the epidermis is continually shed with hair, sweat, and sebaceous grease into the central cavity. The dermoid slowly enlarges in consequence, and a tumour of this kind, no bigger than a pea or a walnut at birth, may in twenty years be as big as a coco-nut. When such a tumour is opened and the contents cleared away the skin lining its cavity will sweat when the patient sweats, and the fluid can be seen oozing from the sweat

ducts. The skin lining the tumour is sensitive to the prick of a pin.

The most impressive examples of functioning tumours arise

FIG. 46.—Ovarian dermoid. The skin, hair, teeth, and nerve tissue which it contains may be regarded as representing the cephalic end of an ovarian embryoma. From a single woman aged twenty-six. (Museum, Middlesex Hospital.)

in the ovary, and the growth of our knowledge concerning these tumours reads like a fairy tale. Fifty years ago dermoids puzzled pathologists, but in the interval much knowledge has been gained concerning them. It is now established that these

tumours are the products of ova which have become active and developed into ill-conditioned fœtuses independent of the stimulus of spermatozoa. *An ovarian fœtus produced in this way is called an embryonal rudiment.*

Before dealing with the relation of ovarian embryomas to the products found in their sacs some matters must be considered relating to the activities of a normal uterine fœtus.

In the mid-period of gestation the fœtus floats freely in a hydrosphere formed by amnionic fluid. There are four sets of organs functional —the placenta on which its life depends, the kidneys, choroid plexuses, and skin with its epitrichium. The urine discharged by the kidneys mingles with the amnionic fluid. If the urine is hindered from escaping, the kidneys will become transformed into hydronephrotic sacs. The choroid plexuses secrete cerebro-spinal fluid, and if it cannot escape from the fourth ventricle hydro-

FIG. 47.—Harlequin fœtus.

cephalus occurs. This is a common malformation, and museums contain examples by the score. The skin is active, lanugo grows freely, and the epidermis develops the epitrichium (described by Welcker in 1864) which furnishes the soapy vernix caseosa so conspicuous on the skin of a newborn child. In an embryo the whole of the epidermis consists of a single layer of cells. Later this becomes double and the superficial layer is the epitrichium. About the eighth month the epitrichium is cast off, mixed with grease from the sebaceous glands, and lanugo. Occasionally it persists and forms a collodion-like envelope over the fœtus, producing the comic appearance which recalls the harlequin (Fig. 47). The epitrichium persists in aquatic creatures such as frogs and salamanders; it protects them from maceration. The human fœtus is an aquatic animal while disporting in the hydrosphere; the epitrichium and the vernix caseosa protect it from maceration.

Normal pregnancy terminates with the expulsion of the fœtus and the by-products of its glandular organs. If all goes well it becomes an air-breathing mammal. It sometimes happens that a fœtus cannot be expelled. In this event the placenta, on which its life depends, ceases to act and slowly disappears. The amnionic fluid dries up, the fœtus dies, shrinks, mummifies, and eventually its tissues become calcified.

The life of an intra-uterine fœtus is dominated by the placenta.

The Embryoma.

An embryoma, the essential element of an ovarian dermoid, may contain nearly every organ required for the equipment of a fœtus : skin with its essential glands, hair and teeth, pigment, and nerves, limb-buds with cartilage and bone, fat and muscle, brain and spinal cord, nerves and ganglia, an eye, gut, and Auerbach's plexus (Nicholson) ; trachea and thyroid gland, liver tissue (Warwick).

For many years pathologists limited their search to the his-

tology of these lumps. Professor S. G. Shattock critically reconstructed some of the sections. For him nervous tissue collected around a central tube is a syringo-myelus. Grey matter enclosed in dura mater is a miniature brain. C. E. Shattock removed an ovarian tumour the size of a bantam's egg from a girl aged two and half years. The tumour on median section disclosed an embryoma which can be interpreted as an acormus-embryoma ; it is trunkless and limbless, consisting only of a hydrocephalic head. The vault is membranous and the base cartilaginous. A piece of hairy scalp is attached to the head and, near it, some tissue consisting of groups of ganglia furnished with large typical nerve cells. This specimen is preserved in the museum of the Royal College of Surgeons.

The importance of interpreting the gross features of embryomas, with the aid of histological details, adds a new interest to these deformed lumps ; they seem like misdirected embryologic energy. The ovarian dermoid shown in Fig. 46 is actually the size of a coco-nut and contained the usual mixture of grease and hair. A remnant of the ovary is seen at the lower pole of the tumour and immediately adjacent there is a patch of skin covered with reddish hair resembling a piece of scalp. Two teeth, an incisor and a bicuspid, are fully erupted. The tissue immediately under the skin contains a collection of nerve tissue with cells like those in grey matter of the brain. The skin, hair, teeth, and nerve tissue may be interpreted as representing the cephalic end of an ovarian embryoma (Warwick). The loose matter filling the cyst is furnished by sebaceous glands, hair, and desquamating epidermis. The cyst wall, to meet requirements, grows in a most accommodating manner.

It is certain that an ovarian embryoma contains active organs, especially skin, which is continually discharging sebum and sweat, and shedding epidermic cells and hair. The embryoma has no time limit like a fœtus, not being dependent on a placenta, and though it rarely exceeds the dimensions of a fist

the products of its activity accumulate in the bag which encompasses it and may, in the course of years, amount to three litres or more. Occasionally the pressure of the accumulated organic rubbish bursts the sac and escapes into the peritoneal cavity, which may become so distended that the belly-wall pits on pressure like dough. Sometimes the epithelial elements which escape from the sac engraft themselves on the peritoneum. In such circumstances hundreds of little islets of skin bearing tufts of lanugo dot the peritoneal surface of the intestines, liver, and omentum.

Fig. 48.—Calcified ovarian dermoid containing a coil of hair, and teeth implanted in bone. (Museum, Middlesex Hospital.)

After an embryoma ceases to grow, its capsule, like the membrane of an extra-uterine fœtus, calcifies; the museum of the Middlesex Hospital contains a good example, resembling a coco-nut containing a coil of hair, and three teeth on a plate of bone.

So far we have been dealing with ovarian embryomas in which skin played the prominent part in furnishing waste products. We must now consider some parallel conditions in which mucous membrane is the chief factor.

Multilocular Glandular Tumours of the Ovary.

These are the biggest tumours which grow in women. Some of the tumours I have removed weighed nearly a hundredweight

and even bigger examples have been recorded. The loculi in such tumours vary in size and their walls are lined with soft tissue covered with a single layer of large columnar cells heavily charged with mucin (Fig. 49). The membrane lining the loculi

Fig. 49.—Loculi of an ovarian tumour lined with big mucus-laden epithelium (magnified).

is arranged in depressions, bays, and narrower recesses, recalling in their arrangement the simple glands of the large intestine. The amount of mucus furnished by them is often very great ; as there are no excretory ducts for the escape of the secretion it accumulates in the loculi, which become enormously distended by the products of the cells. It is a gelatinous substance now

called pseudo-mucin. Often the walls of adjacent loculi rupture and allow neighbouring cavities to communicate, and in this way large chambers form. It is not uncommon for a loculus near the periphery of the tumour to burst and allow the contents to escape into the belly. In some of the cases the amount of pseudo-mucin that collects in the belly is almost beyond belief.

A spinster, aged fifty-four, was under my care in 1899 on account of an enlargement of the belly. The physical signs suggested an accumulation of fluid. The pressure was so great as to produce a hernial protrusion as big as a bantam's egg at the navel, and a similar one over the left femoral ring. A tumour could be felt in the pelvis. I removed three gallons of mucin and a mucigenous tumour of the ovary equal in size to a cocoanut. There was a rent in its capsule opening up three loculi, and through this rent the pseudo-mucin secreted by the mucous membrane lining the loculi escaped into the belly. The tumour was easily removed and the patient reported herself in good health five years after the operation.

Many similar cases have been under my care and observation, but all do not end in this simple way. Occasionally, when a mucigenous tumour bursts, clumps of cells escape from the walls and settle on the peritoneum and act as grafts, and become independent tumours, discharging pseudo-mucin, which helps to increase the general mass. In some women hundreds of these pathological glands grow on the serous membrane, and the amount furnished in this way, after the primary tumour has been removed, is so great that it is necessary to open the abdomen annually for the removal of the pseudo-mucin. In removing this material care should be taken to protect the edges of the abdominal incision; it occasionally happens that the epithelial elements in the pseudo-mucin accidentally implanted will grow in the scar and form independent tumours. I have seen them as large as ripe gooseberries.

Surgeons are familiar with these remarkable tumours, concerning which the following facts may be stated: It is not uncommon to find in a woman one ovary occupied with a dermoid and the other converted into a mucigenous cyst. It is not rare to find an ovary transformed into a bilobed tumour one lobe of which is a typical dermoid and the other mucigenous. The inner walls of isolated cavities are often covered with cylindrical epithelium, loaded with mucin, and indistinguishable from the large cells found on the surface and recesses of the rectal polypi so common in children. Mucigenous tumours are often so large that it is only by chance the embryoma is detected. Quite by chance I saw one on the cut surface of a huge tumour. The embryoma presented as a patch of skin, less than 2 cm. square, bedecked with a tuft of delicate lanugo (Fig. 50).

Fig. 50.—Segment of a huge mucigenous ovarian tumour presenting an embryoma, *d*, bedecked with a tuft of lanugo, *h*. (Museum, St. Thomas's Hospital.)

I have studied the histology of these tumours in season and out of season, and often asked myself the question, Why is the intestinal tract rarely demonstrable in the ovarian embryoma? Gradually I have realised that the mucin (or pseudo-mucin) of

these tumours is produced by the gastro-intestinal epithelium of the embryoma, and this, the active agent in the production of mucin, is masked by the accumulated products of its own activity.

The matter may be briefly expressed in this way: In the

Fig. 51.—Un Chiffonnier.

common kind of ovarian embryoma the cutaneous elements are conspicuous; the products resulting from the activity of the skin preponderate and make up the bulk of the tumour mass. In mucigenous ovarian tumours the so-called "colloid stuff" is furnished by the gastro-intestinal epithelium of the embryoma.

In dermoid tumours skin prevails.

In mucigenous tumours mucous membrane prevails. But both arise in ova which segment independently of the stimulus of spermatozoa.

In France the man who picks up rubbish in the streets and collects it in the *hotte* on his back is called a chiffonnier. The membranes of a uterine fœtus, or the sac of an ovarian embryoma, serve to remind us of the *hotte* of the chiffonnier. The simile helps to illustrate the thesis set out in the beginning of this lecture : *Many tumours become manifest by the accumulation of the products of their own activity.*

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